HP 340B

340B
NOISE FIGURE METER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 340B

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CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

MANUAL CHANGES

MODEL 340B

NOISE FIGURE METER

Manual Serial Prefixed: 416-
Manual Printed: Aug 1965

MAKE ALL CORRECTIONS IN THIS MANUAL ACCORDING TO ERRATA BELOW, THEN CHECK THE FOLLOWING TABLE FOR YOUR INSTRUMENT SERIAL PREFIX (3 DIGITS) OR SERIAL NUMBER (8 DIGITS) AND MAKE ANY LISTED CHANGE(S) IN THE MANUAL.

► NEW ITEM.

SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES	SERIAL PREFIX OR NUMBER	MAKE MANUAL CHANGES
ALL	ERRATA		

ERRATA

Figure 2-2:
Change recommended operating current to:

S347A	250 mA
G347A	200 mA
J347A	200 mA
H347A	175 mA
X347A	200 mA
P347A	175 mA

CAUTION ◄

Do NOT exceed 250 mA under any conditions.

Figure 4-8:
J103: Starting with pin 1, number the pins clockwise instead of counterclockwise.

Section IV Page 5, D. CHECKING AGC ACTION, change steps 3) and 4) to read:
3) Set Model 606A output to -60 dBm and adjust INF potentiometer for a 25 dB reading on the 340B meter.

4) Vary Model 606A output from -60 to 0 dBm; the meter pointer should remain between 25 dB and inf.

Page 2-0, Figure 2-1:
Delete "4A" from front panel fuse.

Section IV, Page 8, Paragraph 12 should read:
Compare the indicated noise figure on the gas tube scale (top scale on upper arc) with computed noise figure given below. These figures are given to an accuracy of two decimal places but should be rounded off to one place before use since value of the noise of the gas tube (15.2 dB) is accurate only to one decimal place. In computing NF dB, first compute N_2/N_1 from the formula:

$$\frac{N_2}{N_1} = \log_{10}^{-1} \left(\frac{dB}{10}\right)$$

and then substitute this value in the formula given.

For derivation of these formulas, and other information, see Application Note 57 obtainable from your nearest Hewlett-Packard field office.

Section V, Page 7:
Change V108 to 1932-0018 (same description)

OPERATING AND SERVICE MANUAL

MODEL 340B
NOISE FIGURE METER

SERIALS PREFIXED: 416 -

SEE APPENDIX
FOR OTHER SERIALS

00107-5

Printed: AUG 1965

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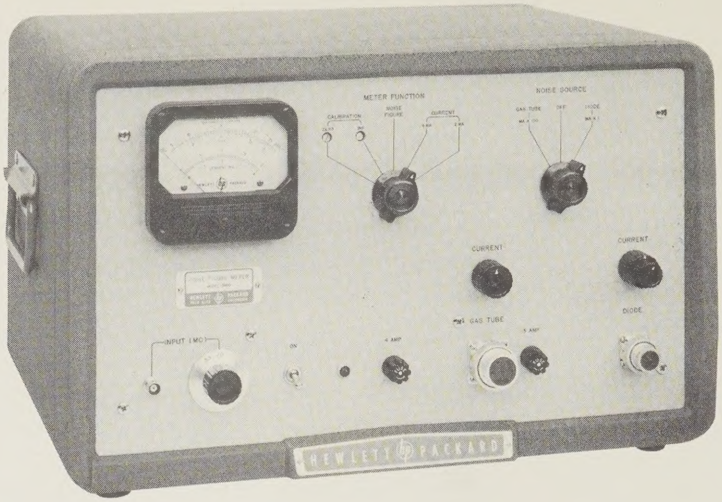


Figure 1-1. Model 340B Noise Figure Meter

Table 1-1. Specifications

Noise Figure Range:
5.2 db Noise Source: 0 to 15 db, indication to infinity.
15.2 db Noise Source: 3 to 30 db, indication to infinity.

Accuracy:
Noise Diode Scale: ±1/2 db, 0 to 15 db.
Gas Tube Scale: ±1/2 db, 10 to 25 db, ±1 db, 3 to 10 db and 25 to 30 db.

Input Frequency: 30 or 60 mc selected by switch. Other frequencies optional.

Bandwidth: 1 mc minimum

Input: -60 to -10 dbm (noise source on). Corresponds to a gain between noise source and 340B of: 5.2 db noise source: approximately 50 to 100 db, 15.2 db noise source: approximately 40 to 90 db.

Input Impedance: 50 ohms nominal

Recorder Output:
1 ma maximum into 2000 ohms maximum.

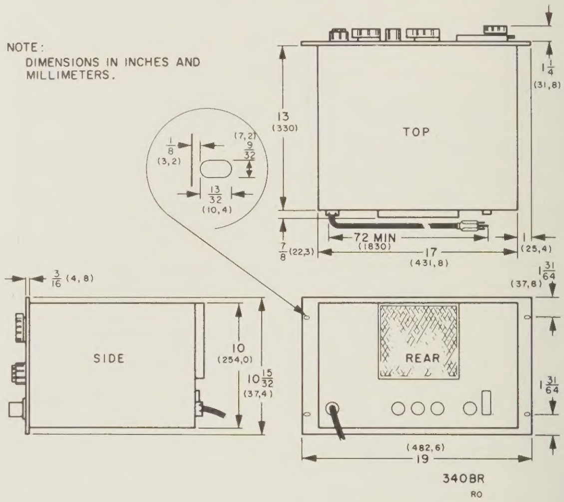
AGC Output:
Nominal 0 to -6 volts from rear binding posts.

Power Input: 115/230 volts ±10%, 50 to 60 cps, 185 to 435 watts depending on noise source and line voltage.

Power Output: Will operate 343A, 345B, 347A, or 349 sources.

Net Weight:
Cabinet Mount: 40 lb (18, 0 kg)
Rack Mount: 34 lb (15, 3 kg)

Dimensions:
Cabinet Mount: 20-3/4 in. wide, 12-3/4 in. high, 14-1/2 in. deep (527 x 324 x 368 mm)
Rack Mount:



Accessory Furnished: 340A-16A, 6-ft (152, 4 mm) cable for connecting ⓗⓟ 340B to the ⓗⓟ 349A or to any ⓗⓟ 347A Waveguide Noise Source.

Accessories Available:
ⓗⓟ Model 343A VHF Noise Source, 10 to 600 mc
ⓗⓟ Model 345B IF Noise Source, 30 to 60 mc
ⓗⓟ Model 347A Waveguide Noise Source for S, G, J, H, X, and P bands
ⓗⓟ Model 349A UHF Noise Source, 400 to 4000 mc

SECTION I
GENERAL DESCRIPTION

1-1 INTRODUCTION

Model 340B Noise Figure Meter with an appropriate noise source automatically measures and continuously displays the noise figure of the receiver or amplifier to which it is attached. Noise figure of a receiver or amplifier is a measure of the deterioration of a signal-to-noise ratio caused by the amplifying device. Specifically, noise figure is the signal-to-noise ratio at the input of the device divided by the signal-to-noise ratio at the output of the device, and expressed in db.

The ⓗⓟ Model 340B Noise Figure Meter is designed for use with radar and other microwave receivers which have an intermediate frequency of 30 or 60 megacycles and with amplifiers tuned to 30 or 60 mc. It may also be used with devices tuned to other frequencies and with traveling-wave-type amplifiers if a converter is used to obtain a 30 or 60 mc signal.

Model 340B provides a convenient and simple method of measuring and minimizing the noise figure of receivers and amplifiers. Besides making measurements of noise figure automatically, this instrument can be used to measure noise figure by the twice power method. In this method, just enough power is added to the input of the device being tested to double the output power of the device. Thus, the added power is equal to the equivalent noise at the input, and noise figure can be determined by referring the added noise to theoretical noise, KT_0B.

1-2 NOISE SOURCES

The Hewlett-Packard Company manufactures two types of noise sources which operate with the Model 340B. The Noise Figure Meter provides both power to operate these sources and circuitry for measuring and adjusting the noise source current.

MODEL 343A VHF NOISE SOURCE

Model 343A VHF Noise Source contains a temperature-limited diode and circuitry to obtain an excess noise of 5.2 db (nominal) at a source impedance of 50 ohms. The output noise spectrum is 10 to 600 mc.

MODEL 345B IF NOISE SOURCE

The Model 345B IF Noise Source is also a temperature-limited diode. It has four output impedances as selected by a rotary switch. The noise spectrum is center tuned at both 30 and 60 mc as selected by a switch.

MODEL 347A WAVEGUIDE NOISE SOURCES

Each Model 347A Waveguide Noise Source consists of an appropriate section of waveguide in which is mounted an argon-filled gas-discharge tube. Accurate measurements are assured, since careful design has kept the standing-wave-ratio low in both the "on" and "off" conditions of the tube. The Waveguide Noise Sources are available in S, G, J, H, X and P bands for operation from 2.6 kmc to 18.0 kmc and each covers a full waveguide band.

1-3 DAMAGE IN TRANSIT

This instrument should be thoroughly inspected when it is received. If any damage is evident, contact the carrier immediately. For any assistance, consult your nearest Hewlett-Packard Sales and Service Office (see list at back of this manual).

1-4 230 VOLT OPERATION

Unless otherwise requested by the customer, this instrument is connected for operation from 115 volts, 50 to 60 cps. Directions for converting this instrument for 230 volt operation are given in par. 4-3.

1-5 AIR FILTER

The rack model, 340BR, contains an air filter which must receive an oil coating before the instrument is placed in normal use. This will prevent excessive dirt from entering the instrument. We recommend the use of Research Products Co. No. 3 Filter Coat.

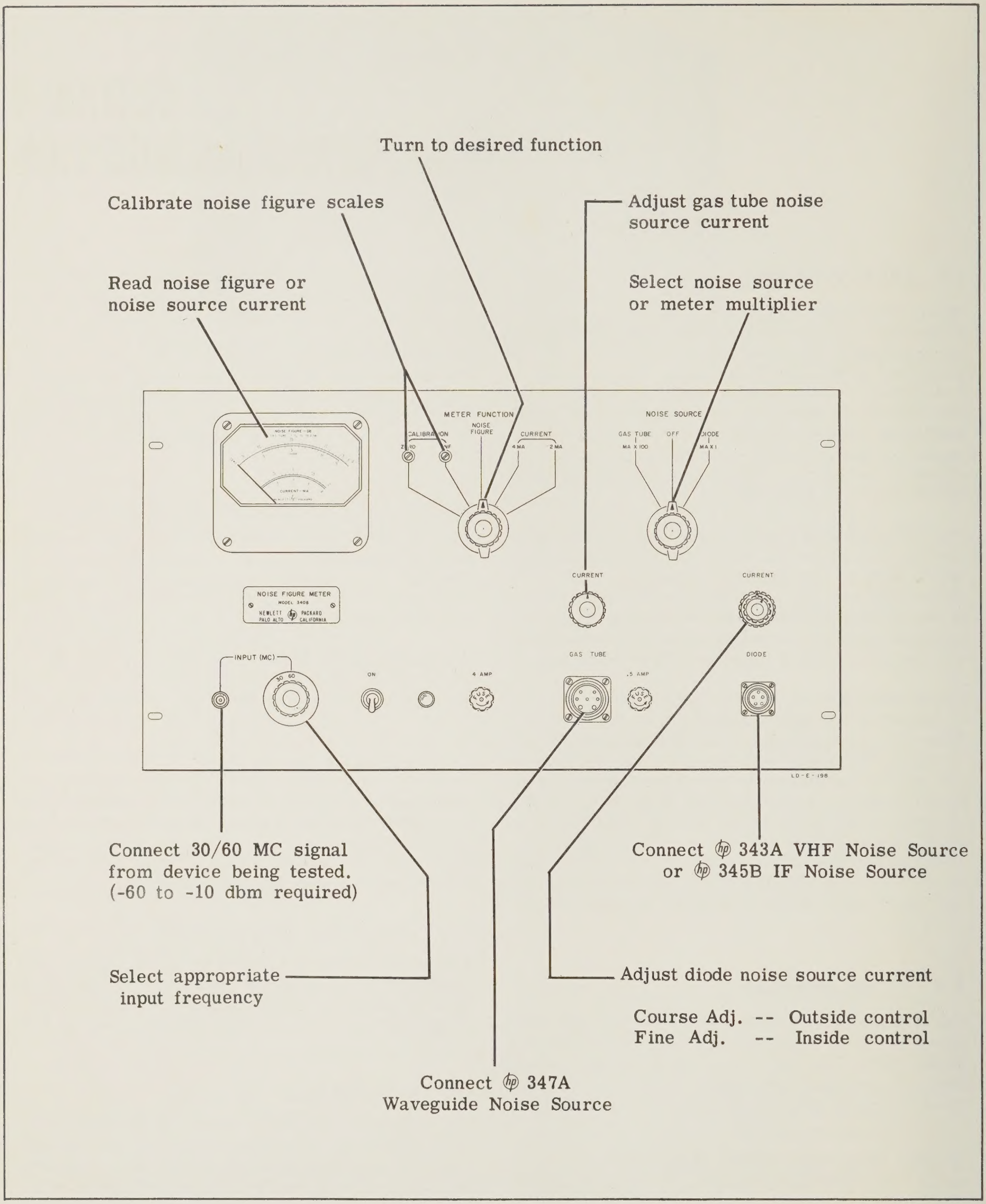


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Figure 2-1. Operating Controls

SECTION II
OPERATING INSTRUCTIONS

2-1 INTRODUCTION

This section contains instructions for measuring the noise figure of microwave receivers and of amplifiers tuned to 30 or 60 mc. Two methods of measurement are illustrated. First is the automatic method by which the noise figure of the unit being tested is automatically displayed on the meter face. Second is the "twice power" or manual method where the 340B becomes a sensitive power level indicator.

2-2 CONTROLS AND TERMINALS

Besides the controls described in Figure 2-1, there are less frequently used controls and terminals located at the rear of the unit. These are:

A. NOISE FIGURE SWITCH

In the AUTO. setting, the 340B makes continuous and automatic measurements of noise figure. In the MANUAL position the 340B is used as a power level indicator to make noise figure measurements by the "twice power method".

B. PULSE RATE ADJ.

This control adjusts the free-running rate of the timing multivibrator, V104. This control may be set to any convenient position to eliminate beat effects in an over-all system, such as harmonics of the power line frequency. Such effects will be noticeable usually as wide excursion meter flutter at the beating frequency. Repositioning this adjustment in no way effects the basic accuracy or operation of the 340B.

C. RECORDER

This output jack is in series with the meter as is shown in schematic diagram. The output circuit will supply 1 ma into a maximum of 2000 ohms. The additional impedance of the recorder may change the meter calibration. To correct for this effect, check the INF. CALIBRATION, and recalibrate this point if necessary. This procedure is illustrated in Figure 2-5.

D. DIODE CURR. ADJ.

This control limits the plate current of the diode noise source. It must be adjusted for the particular diode in use.

Make the adjustment as follows:

1) Set the CURRENT control at minimum (fully counterclockwise).

2) Connect the 343A or 345B Noise Source to the DIODE connector.

3) Set the NOISE SOURCE switch to the DIODE - MA X1 position, and the METER FUNCTION switch to the CURRENT - 4 MA position.

4) Allow a few minutes for warmup.

5) Slowly rotate the CURRENT controls clockwise toward maximum while readjusting the DIODE CURR. ADJ. control to maintain the current below 4 ma.

6) With the CURRENT controls at maximum (fully clockwise), set the DIODE CURR. ADJ. control to provide 4 ma of current.

CAUTION

The maximum plate current rating of the diode used in the 343A VHF Noise Source is only 5 ma. Incorrect adjustment of the above controls may exceed this rating. The maximum current, therefore, should always be set at 4 ma or less to prevent damage to the diode. The impedance setting of the 345B does not effect the DIODE CURR. ADJ. procedure.

E. AUX. INPUT AND OUTPUT VOLTAGES

As an optional feature on the rack model, 340BR, three connectors can be installed at the rear of the

instrument. If this feature has been included, these are the additional connectors:

1) "BNC" INPUT connector.

2) Seven pin GAS TUBE connector.

3) Five pin DIODE connector.

These connectors are wired in parallel with the front panel terminals. Either set may be used singly.

F. AGC VOLTS

The tuned amplifier AGC voltage appears at these terminals. This voltage is useful in special applications such as noise figure measurements of TWT amplifiers, which require a knowledge of the TWT gain in relation to changes in noise figure.

The AGC voltage may also be used to indicate the power supplied to the 340B INPUT by the system under test. This is accomplished by correlating the AGC voltage to the input power using a source such as the ⓗⓟ Model 606 or 608 Signal Generator. With the generator set to CW, and tuned to 30 or 60 mc, connect the output to the 340B INPUT connector. Measure the AGC voltage, as a function of the signal generator output (in dbm), with a voltmeter whose input impedance is 10 megohms or greater, e.g. the ⓗⓟ Model 410B or 412A VTVM. By using this information the VTVM may now be used as a powermeter to monitor the over-all system under test. For utmost accuracy the 340B should be operated on a regulated line in this application, as variations of the filament supply voltage will change the AGC/input power correlation.

2-3 RELATIVE NOISE FIGURE MEASUREMENTS

In most cases absolute values of noise figure are of academic interest only. What is really desired is to optimize the noise figure of a particular unit. For this application, the following procedures are sufficient.

2-4 WARM-UP

Before making preliminary adjustments or before measurements are made, the ⓗⓟ 340B should be allowed at least a five minute warm-up period to stabilize at a normal operating temperature.

2-5 MECHANICAL ADJUSTMENT OF METER ZERO

When meter is properly zero-set, pointer rests over the zero calibration mark on the meter scale when instrument is a) at normal operating temperature, b) in its normal operating position, and c) turned off. Zero-set as follows to obtain best accuracy and mechanical stability:

1) Allow the instrument to operate for at least 20 minutes; this allows meter movement to reach normal operating temperature.

2) Turn instrument off and allow 30 seconds for all capacitors to discharge.

3) Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

4) Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer overshoots zero, repeat steps 3 and 4.

5) When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step you must repeat steps 3 through 5.

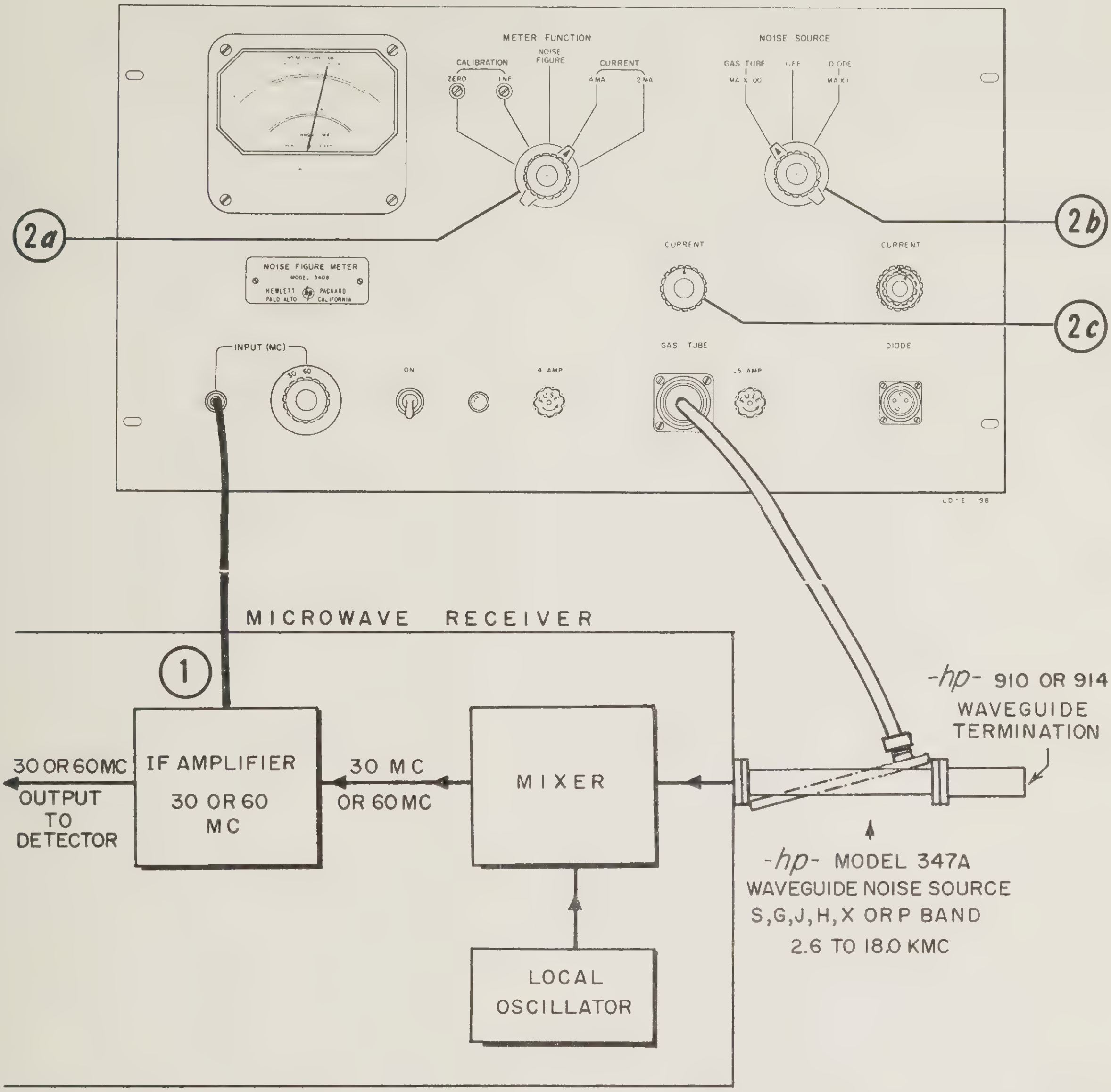
2-6 OPERATING PROCEDURES

The operating procedures are given pictorially in the following Figures:

- 2-2 Using a Waveguide Noise Source Setup to Measure Noise Figure
- 2-3 VHF Noise Source Setup to Measure Noise Figure
- 2-4 IF Noise Source Setup to Measure Noise Figure
- 2-5 Automatic Measurement of Noise Figure of a Microwave Receiver
- 2-6 Automatic Measurement of Noise Figure of an IF Amplifier or VHF System
- 2-7 Manual Measurement of Noise Figure Using an ⓗⓟ 347A
- 2-8 Manual Measurement of Noise Figure Using an ⓗⓟ Diode Noise Source

Figures 2-2 through 2-4 are basic to the operation of the Noise Figure Meter. They contain instructions for connecting and using the ⓗⓟ noise sources and for setting the noise source current. The other figures supplement these basic setup procedures.

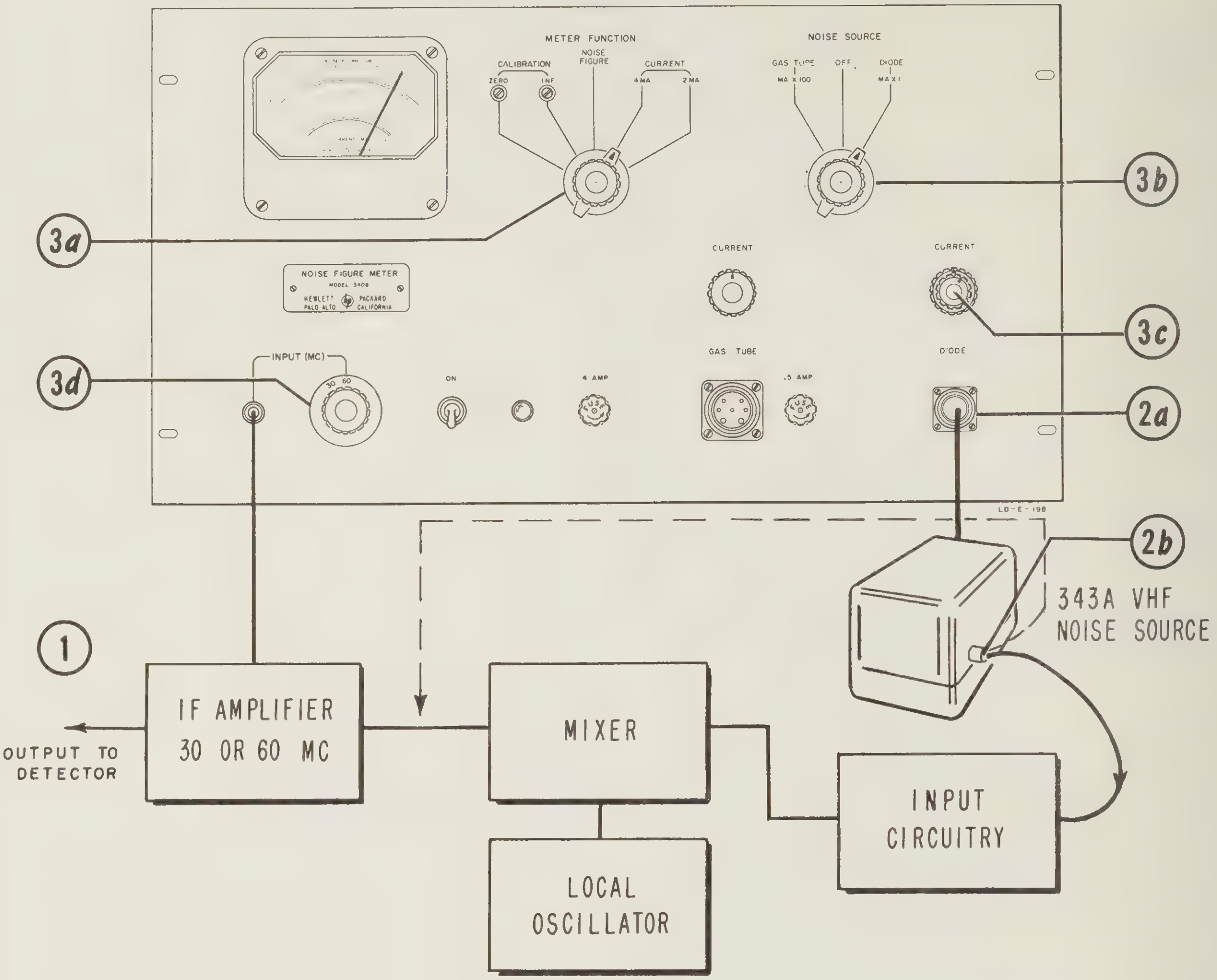
NOTE: A slight upscale reading on the meter is normal when the METER FUNCTION switch is set to either INF or NOISE FIGURE even though there is no signal connected to the INPUT. Meter current is produced by the thermal and shot noise in the amplifier circuitry.



1. Connect to i-f amplifier where level (with noise source on) is between -60 and -10 dbm. Corresponds to 40 db minimum gain between hp 347A and 340B.
2. To adjust Gas Tube Current,
   a) Set to appropriate current scale
   b) Set to Gas Tube
   c) Adjust current to value indicated in chart

Model	Tube	Gas	Recommended Operating Current
S347A	hp 1971-0002	Argon	250 ma
G347A	hp 1971-0004	Argon	250 ma
J347A	hp 1971-0004	Argon	250 ma
H347A	hp 1971-0011	Argon	150 ma
X347A	hp 1971-0001	Argon	200 ma
P347A	hp 1971-0003	Argon	200 ma
349A	hp 1971-0011	Argon	150 ma

Figure 2-2. Using Gas Tube Noise Source Setup to Measure Noise Figure



1. MODEL 340B -
   Connect to IF Amplifier where the level is between -60 and -10 dbm when the noise source is turned on. This corresponds to a minimum gain of 50 db between the hp 343A and the 340B.

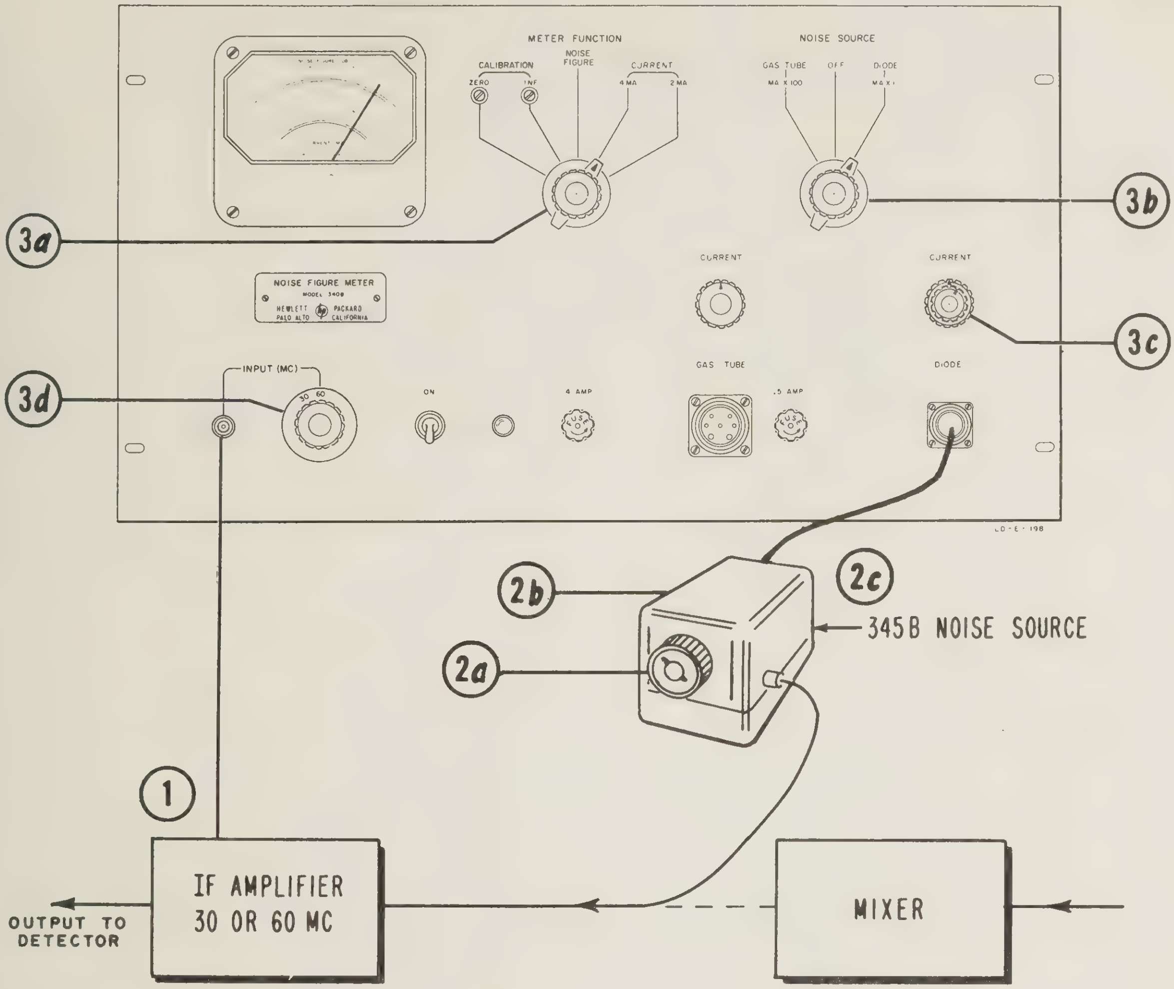
2. MODEL 343A -
   a) Connect 343A to DIODE connector.
   b) Connect output of 343A to measure over-all system or IF Amplifier noise figure*.

3. Set Model 340B controls.
   a) Select current scale.
   b) Set to DIODE.
   c) Adjust to CURRENT** indicated on 343A.
   d) Set to frequency of IF Amplifier.

* Source impedance of 343A is 50 ohms and must be matched to IF Amplifier or system input impedance to avoid mismatch errors.

** If correct current value cannot be obtained, see paragraph 2-2D.

Figure 2-3. VHF Noise Source Setup to Measure Noise Figure



1. Connect to IF Amplifier where level (noise source on) is between -60 and -10 dbm (corresponding to 50 db minimum gain between ⓗⓟ Model 345B and the Noise Figure Meter.)

2. Set 345B controls.
   a) Select impedance which simulates mixer impedance, and note plate current required.
   b) Set to frequency of IF Amplifier (30 or 60 mc).
   c) Connect 345B to DIODE connector.

3. Set Noise Figure Meter controls.
   a) Select current scale.
   b) Set to DIODE.
   c) Adjust to CURRENT* indicated by 345B IMPED. switch.
   d) Set to frequency of IF Amplifier.

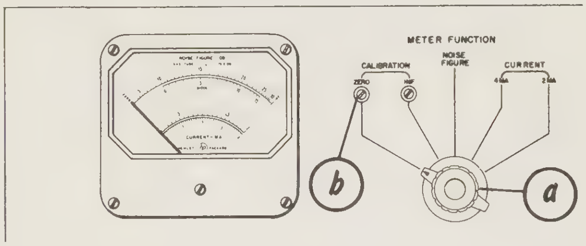
---

* If correct current value cannot be obtained, see paragraph 2-2D.

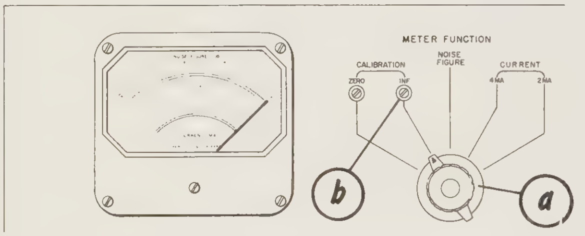
Figure 2-4. IF Noise Source Setup to Measure Noise Figure

Connect equipment and adjust gas tube current as shown in Figure 2-2.

(1) SET NOISE FIGURE switch (back of 340B) to AUTO.

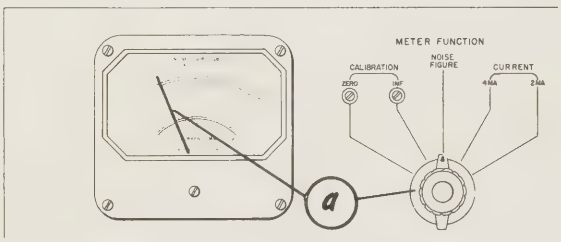


(2) Adjust zero set.
a) Set to ZERO.
b) Use screwdriver to set pointer to ZERO.



(3) Adjust infinity set
a) Set to INF.
b) Use screwdriver to set pointer to INF.

NOTE - If pointer cannot be set to INF. more gain is required between the noise source and the input to the 340B.



(4) Measure Noise Figure.
a) Set to NOISE FIGURE and read noise figure on GAS TUBE scale of meter. (See NOTE at the end of this section.)

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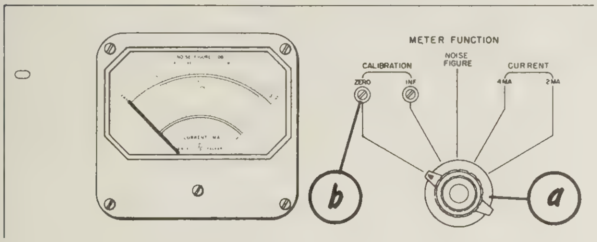
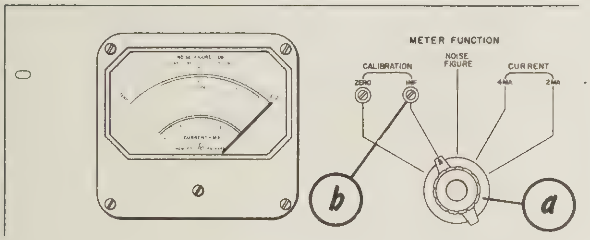
Figure 2-5. Automatic Measurement of Noise Figure of a Microwave Receiver

Connect equipment and adjust diode current as shown in Figures 2-3 and 2-4.

(1) Set NOISE FIGURE switch (back of 340B) to AUTO.

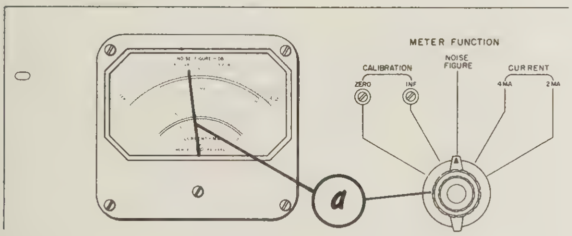


(2) Adjust zero set.
a) Set to ZERO.
b) Use screwdriver to set pointer to ZERO.



(3) Adjust infinity set.
a) Set to INF.
b) Use screwdriver to set pointer to INF.

NOTE - If pointer cannot be set to INF, more gain is required between the noise source and the 340B.



(4) Measure Noise Figure.
a) Set to NOISE FIGURE and read noise figure on DIODE scale of meter. (See NOTE at the end of this section.)

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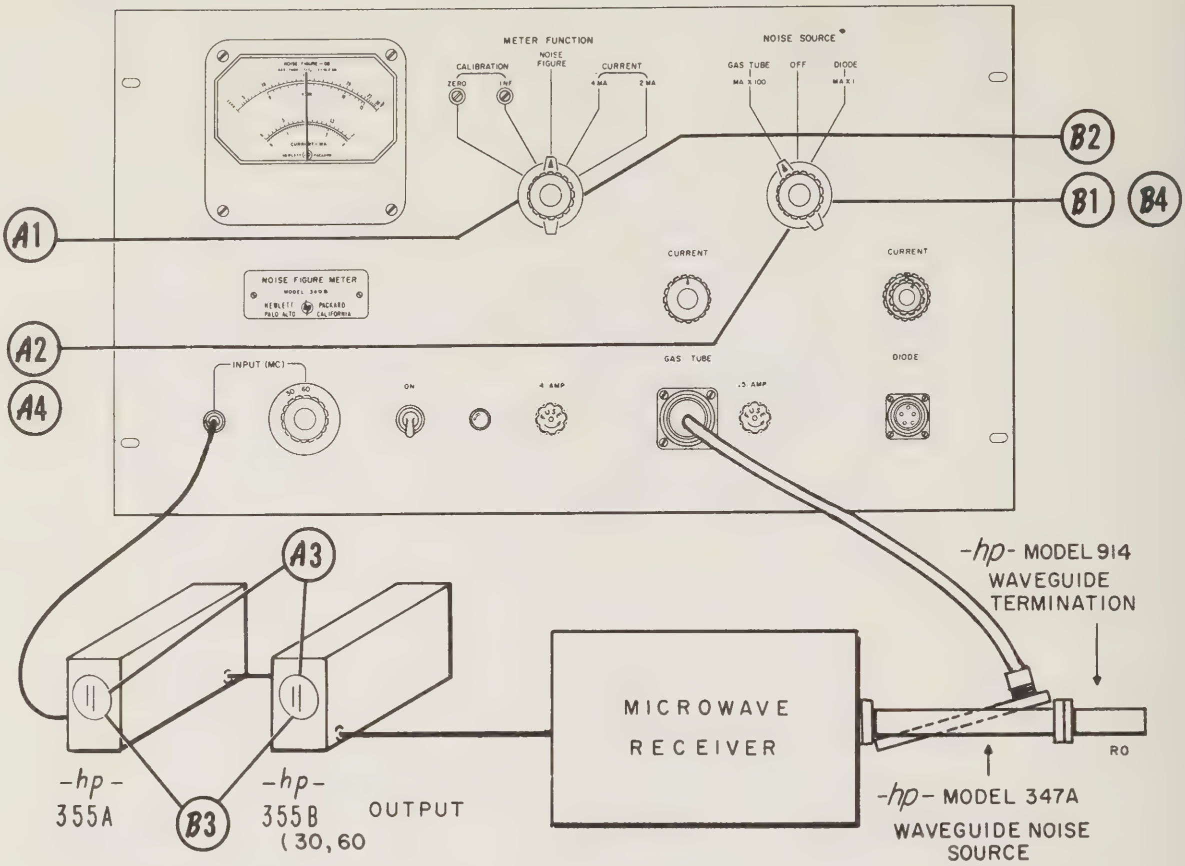
Figure 2-6. Automatic Measurement of Noise Figure of an Amplifier or VHF System



1. Adjust noise source current as in Figure 2-2.

2. Set NOISE FIGURE switch (back of instrument) to MANUAL.

METHOD A

A1 Set to NOISE FIGURE.
A2 Set to GAS TUBE.
A3 Set attenuator for a full scale meter reading.
A4 Set to OFF.
A5 Read noise figure from Gas Tube scale.

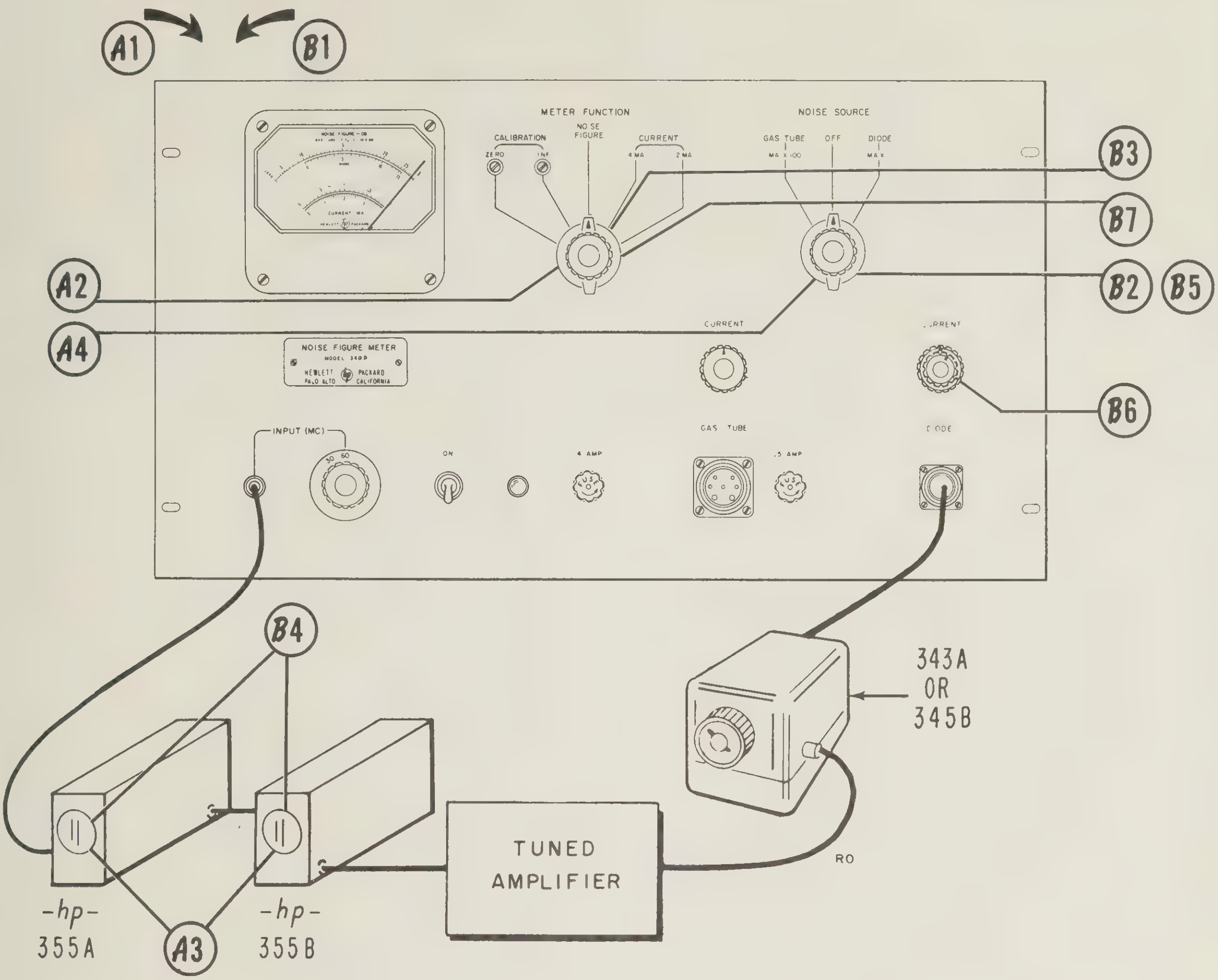
METHOD B

B1 Set to OFF.
B2 Set to NOISE FIGURE.
B3 Set attenuator for convenient current scale reading > 1/4 scale (I min.).
B4 Set to GAS TUBE. Read current scale (I max.).
B5 Calculate noise figure:

$$F = 15.2 - 10 \log \left(\frac{I_{max.}}{I_{min.}} - 1 \right).$$

(See NOTE at the end of this section.)

Figure 2-7. Manual Measurement of Noise Figure Using an ⓗⓟ 347A



Adjust noise source current as in Figure 2-3, or Figure 2-4.

METHOD A

A1 Set NOISE FIGURE switch to MANUAL.
A2 Set to NOISE FIGURE.
A3 Adjust attenuator for full scale reading with NOISE SOURCE switch at DIODE.
A4 Turn to OFF.
A5 Read noise figure from Diode scale.

METHOD B

B1 Set NOISE FIGURE switch to MANUAL.
B2 Set to OFF.
B3 Set to NOISE FIGURE.
B4 Adjust Attenuator for a current scale reading of 1/4 scale.
B5 Turn to DIODE.
B6 Adjust to double reading of B4.
B7 Turn to CURRENT; read current (I).
B8 Calculate noise figure:

$$NF_{(db)} = 10 \log 20\, IR$$

Where: I = Diode current (amp)
R = 345B setting (ohms)
R = 50 ohms for 343A

Figure 2-8. Manual Measurement of Noise Figure Using an ⓗⓟ Diode Noise Source

2-7 USE OF AN EXTERNAL METER

The 340B Noise Figure Meter uses a 1 ma full scale dc meter to indicate noise figure and noise source current. For remote readout applications, an external meter may be connected to the RECORDER jack located at the rear of the instrument. A meter identical to that used in the instrument may be obtained from the factory. (See Section V for part stock number). For increased accuracy in reading low noise figures, a more sensitive meter may be connected in the same manner. An external meter may be calibrated in terms of noise figure (in db) by using Table 2-1.

The additional impedance created by adding an external meter may affect the calibration of the meter circuit. The INF CALIBRATION should be checked and reset if necessary (see Figure 2-5).

WARNING

The INF CALIBRATION control is adjusted to a value of 1 ma. This is the full scale current of the meter used in the 340B. If a more sensitive meter is used as discussed above, the meter should be replaced by its equivalent resistance. The INF CALIBRATION point should then be checked, and reset if necessary. Set the METER FUNCTION switch to NOISE FIGURE and then connect the meter. When using an external meter whose snesitivity is greater than 1 ma full scale, caution should be exercised. Under the following conditions the meter will be driven off scale:

-- Turning off the noise source

-- Setting the METER FUNCTION switch to INF CALIBRATION with external meter connected

-- Measuring a noise figure which reads off scale

2-8 METER OFFSET

The METER FUNCTION switch circuitry of the 340B is arranged so that in NOISE FIGURE position the 340B can supply a negative bias current to an external meter or recorder (controlled by the ZERO calibration control). This offset current can be read on the internal meter in the ZERO set position of the METER FUNCTION switch because the polarity of the internal meter is reversed.

This feature essentially allows scale expansion for noise figure measurements, when using an external meter of greater sensitivity than the internal meter. This technique, however, does not increase the basic accuracy of the instrument. For optimizing adjustments this technique should prove useful.

Assume that we are using an external meter whose sensitivity is 500 μa full scale. As previously discussed, any noise figure over 5.0 db on the DIODE scale, or 15 db on the GAS TUBE scale, will drive the external meter movement off-scale. By using the offset feature, you can use the external meter to measure noise figures in excess of these limits.

Table 2-1. Meter Scale Current

Gas Tube Noise Figure in db	Diode Noise Figure in db	Current in ma
Zero		0.0000
3.0		.0568
4.0		.0705
5.0		.0872
6.0		.107
7.0		.131
8.0		.160
9.0		.194
10.0	0	.232
10.5	0.5	.253
11.0	1.0	.276
11.5	1.5	.299
12.0	2.0	.324
12.5	2.5	.349
13.0	3.0	.376
13.5	3.5	.403
14.0	4.0	.431
14.5	4.5	.460
15.0	5.0	.489
15.5	5.5	.517
16.0	6.0	.546
16.5	6.5	.574
17.0	7.0	.602
17.5	7.5	.629
18.0	8.0	.656
18.5	8.5	.681
19.0	9.0	.706
19.5	9.5	.729
20.0	10.0	.751
21.0	11.0	.792
22.0	12.0	.828
23.0	13.0	.858
24.0	14.0	.884
25.0	15.0	.905
26.0		.923
27.0		.938
28.0		.950
29.0		.960
30.0		.968
INF.		1.000

Consider the following example:

Assume that the noise figure reading of the 340B is 6. 5 db, on the DIODE scale, and that the external meter is driven off-scale. Offset the 340B to 0 db (DIODE scale) or 10 db (GAS TUBE scale) by the following procedure:

1) With the input signal connected, and the Meter Function Switch set to ZERO, adjust the ZERO CALIBRATION control so that the 340B meter reads 0 db, or 10 db on the GAS TUBE scale.

2) Set the Meter Function switch to NOISE FIGURE and assume that the external meter reads 342. 8 μa.

3) Add to this value the amount of offset current which may be determined by using Table 2 -1. Zero db offset, on the DIODE scale, corresponds to a current of 232 μa. Therefore, the total current, which is a function of the noise figure of the system under test, is 574. 8 μa. Using Table 2-1, this represents a noise figure of 6. 51 db.

2-9 IMPROVING LOW NF MEASURING ACCURACY

The accuracy of the 340B in measuring noise figures of 10 db or less in the microwave frequency bands is ± 1 db. This accuracy may be improved to $\pm 1/2$ db by the following technique. Reduce the excess noise level delivered to the device under test by the 347A Waveguide Noise Source. For example, the normal excess noise output is 15. 2 db, and we reduce this by 10 db. The resultant excess noise applied to the device under test is 5. 2 db. This is the same noise power which is delivered by the hp Diode Noise Sources (see paragraph 1-2). Since we are supplying 5. 2 db of excess noise to the device under test, we can now read the noise figure directly on the DIODE Scale of the panel meter. The accuracy of the 340B when using the Noise Diode Scale is $\pm 1/2$ db. Figure 2-9 illustrates one particular method of reducing the excess noise to 5. 2 db. An hp Model 752C Directional Coupler, terminated with an hp Model 914 Waveguide Termination, is inserted between the Model 347A Waveguide Noise Source and the device under test.

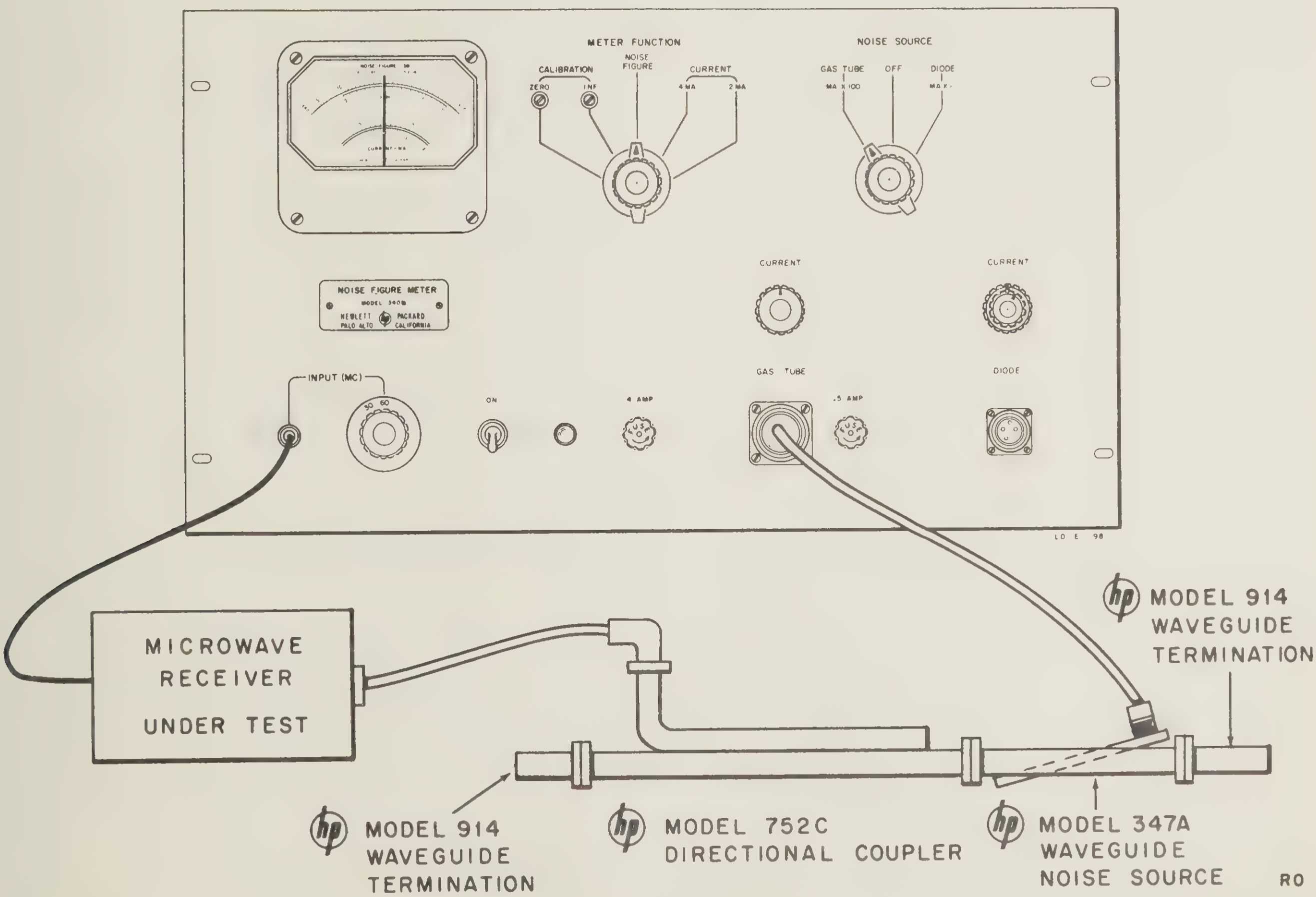


Figure 2-9. Improving Low NF Measurements

This same reduction of 10 db may be obtained by inserting an ⓗⓟ Model 372C Precision Attenuator between the Source and load as shown in Figure 2-10. To obtain a 340B noise figure reading at a convenient point on the gas tube scale, the ⓗⓟ Model 382A Broadband Precision Variable Attenuator may be used. The noise figure of the device under test would be equal to the meter reading minus the 382A attenuation setting.

The above techniques will increase the accuracy of the 340B Noise Figure Meter reading; however, the accuracy of the attenuator or directional coupler which is used must also be considered. The accuracy of the Model 752C is dependent on the microwave receiver frequency. A curve showing the individual attenuation characteristic is supplied with each device.

2-10 SOURCES OF ERROR

In some cases it may be necessary to know absolute values of noise figure. If so, consideration must be given to sources of error in the measurement.

Noise figure is a relative measurement based on power available from a termination (input resistor) at a particular temperature 290 °K. Several factors can cause a difference between measured and actual noise figure. Most important of these factors are:

1) Coupling and transmission line errors.
2) Ambient or termination temperature different from 290° K.
3) Receiver mismatch
4) Noise source mismatch

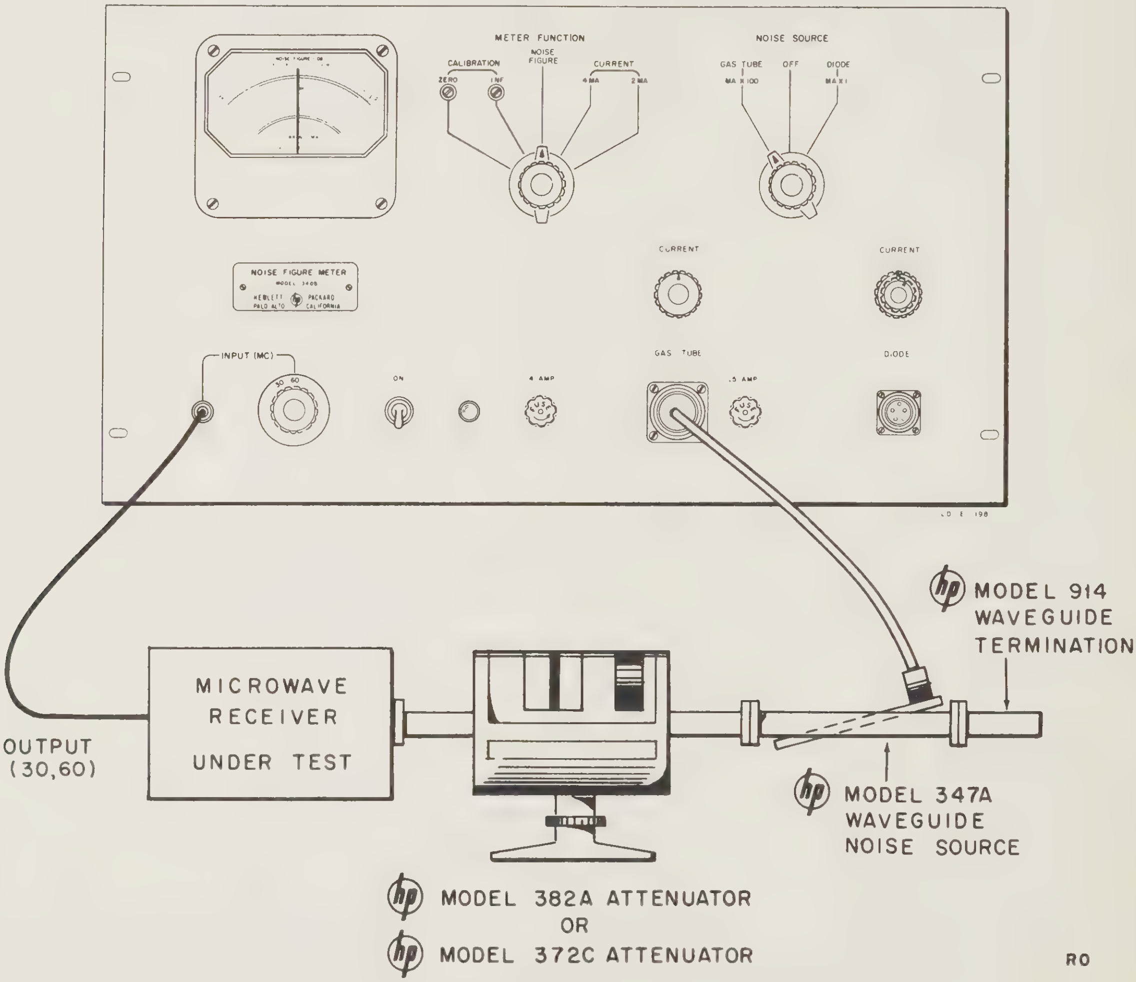


Figure 2-10. Improving Low NF Measurements

First of these sources of error is a function of the coupling of the noise power source to the transmission line and the attenuation of the line. These elements are called "hot loss" and "cold loss" respectively. "Hot loss" is equivalent to the attenuation (insertion loss) of the noise source when the source is turned on. "Cold loss" is the attenuation (insertion loss) when the noise source is off. Figure 2-11 is a plot showing corrections for measured noise figure as a function of hot and cold loss. When using an hp noise source, correction is unnecessary, since error is typically less than 1/4 db.

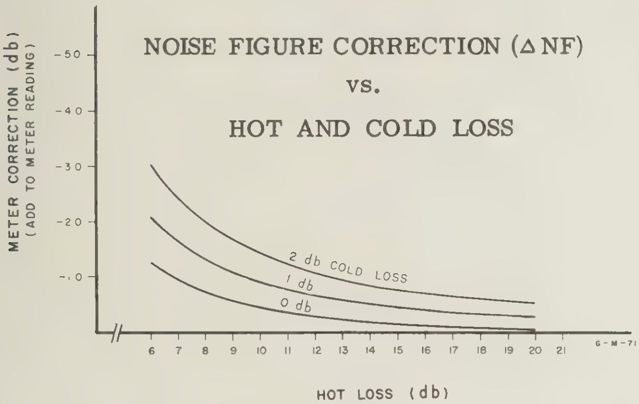


Figure 2-11. Hot-Cold Loss Correction

Figures 2-12 and 2-13 are correction plots for temperature and are direct reading. The following equations express this relationship between actual noise figure and the 340B noise figure reading for different ambient temperatures.

For Diode Noise Sources:

$$NF = 10 \log \left[\log^{-1}\left(\frac{NF_M}{10}\right) - \left(\frac{T}{T_o} - 1\right) \right]$$

For Gas Tube Sources:

$$NF = 10 \log \left[\log^{-1}\left(\frac{NF_M}{10}\right) - \left(\frac{T}{T_o} - 1\right)\left(1 + \log^{-1}\frac{\frac{NF_M}{10}}{33.1}\right) \right]$$

Where:

- NF = actual noise figure
- NF_M = noise figure reading of the 340B
- T = ambient temperature in degrees K
- T_o = reference temperature of 290°K

The equation for the gas tube source holds true if the source is looking into its waveguide load.

To use either of these two graphs:

- -- Locate the intersection of the 340B reading and the appropriate temperature line.
- -- Read the actual noise figure from the vertical axis.

Figure 2-14 graphically displays the mismatch-error limits. It is used in the same manner as the temperature correction graphs, except that there are two intersections which define the maximum possible error. The actual error can fall anywhere between these limits.

Note

The gas-discharge type tubes used in the hp Models 347A and 349A Noise Sources have been re-evaluated and with exception of the G347A and the J347A, have been found to provide values of excess noise other than as originally specified. Therefore, since the Noise Figure Meter is calibrated for use with a gas-discharge type tube which produces 15.2 db excess noise, a correction factor must be applied to all meter readings other than those made with the G347A or the J347A (see Meter Corrections listed below for the specific correction factor necessary for your Noise Source).

Meter Correction for Meter Readings

Noise Source Used	Correction Error
349A	+0.5 db (1000-4000 Mc) +0.4 db (500-1000 Mc)
S347A	- 0.1 db
H347A	+0.5 db
X347A	+0.7 db
P347A	+0.8 db

For example: Assume a reading of 16.0 db using the hp Model H347A with the Noise Figure Meter. The correction factor given for the H347A is +0.5 db; hence, the corrected reading is 16.0 db +0.5 db or 16.5 db.

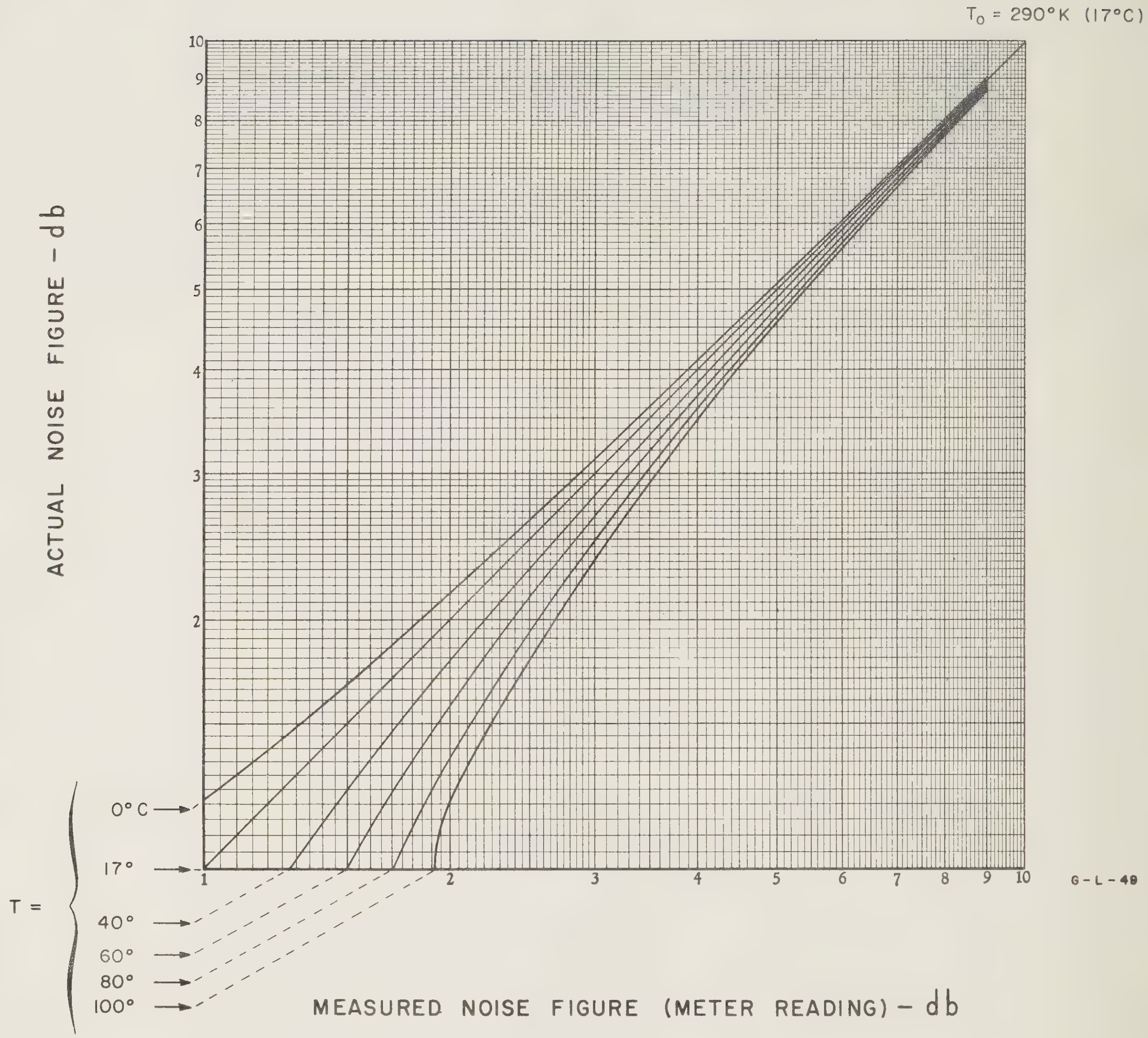


Figure 2-12. Temperature Correction for Model 343A VHF Noise Source and Model 345B IF Noise Source

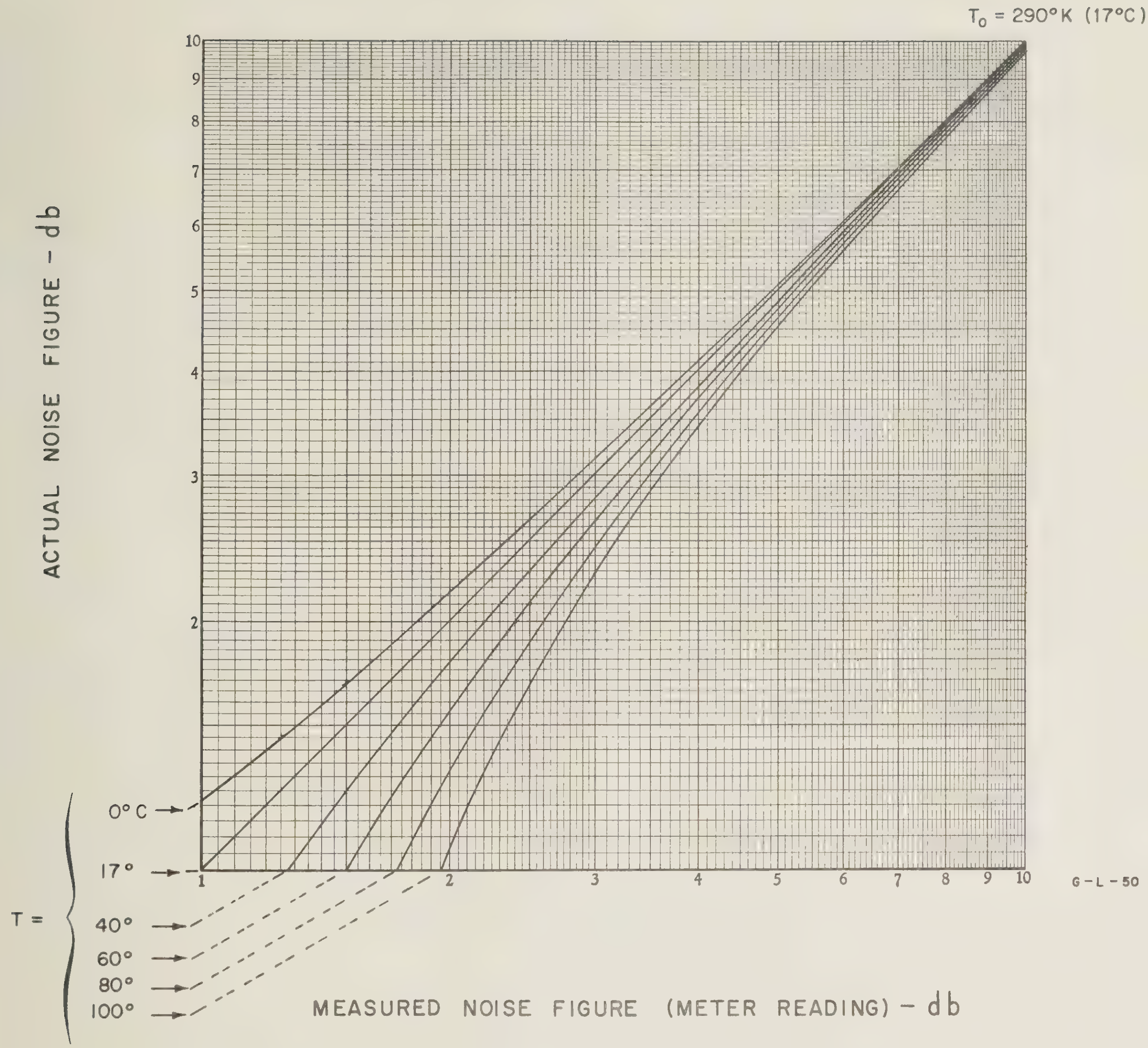


Figure 2-13. Temperature Correction for Model 347A Waveguide Noise Source

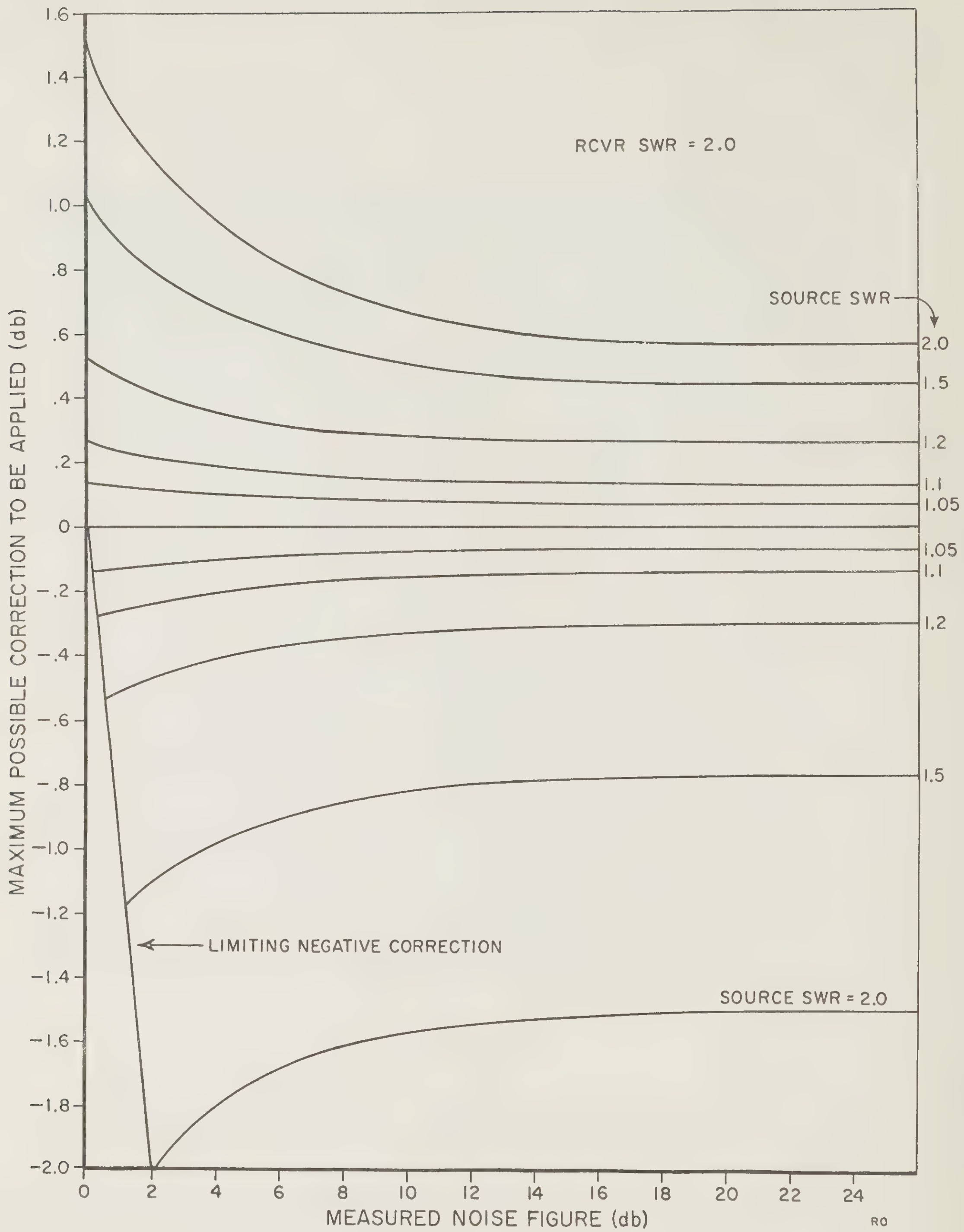


Figure 2-14. Mismatch-Error Limits

Figure 2-14 is calculated from the equation

$$\Delta = 10 \log \left\{ \frac{\left(1-|\rho_g|^2\right)\frac{T_2}{T_o}}{|1-\rho_g\,\rho_l|^2\left(\frac{T_2}{T_o}-1\right)} - \frac{1-|\rho_t|^2}{|-\rho_t\,\rho_l|^2}\left[\frac{1}{\left(\frac{T_2}{T_o}-1\right)} + \frac{1}{\log^{-1}\left(\frac{NF_M}{10}\right)}\right] + \frac{1}{\log^{-1}\left(\frac{NF_M}{10}\right)} \right\}$$

Where:

NF_M = noise figure measured by 340B

Δ = correction in db to be applied to NF_M

ρ_g = noise source reflection coefficient in fired condition

ρ_t = noise source reflection coefficient in unfired condition

ρ_l = receiver reflection coefficient

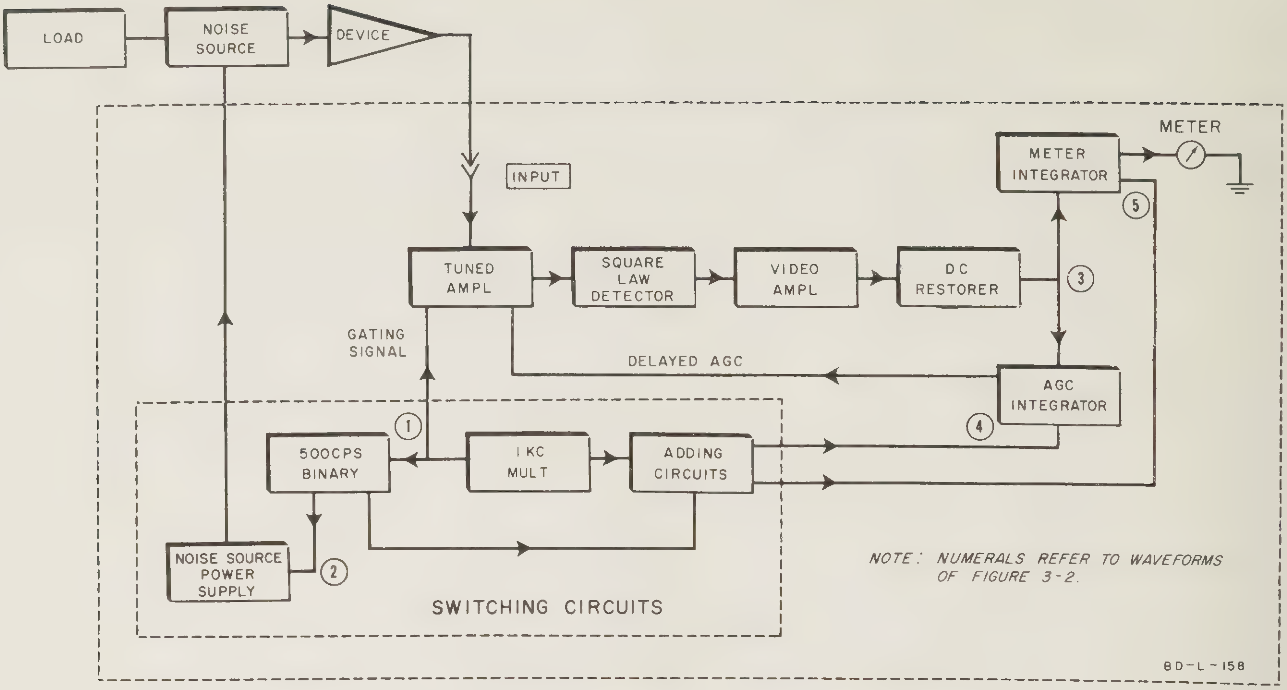


Figure 3-1. Model 340B Block Diagram

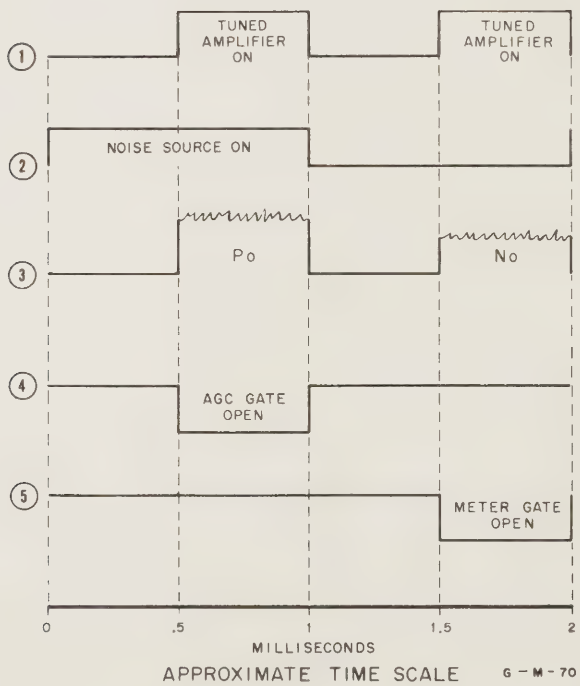


Figure 3-2. Waveforms

SECTION III
THEORY OF OPERATION

3-1 INTRODUCTION

This section contains a discussion and definition of noise figure and describes how the 340B accomplishes this measurement. The over-all circuit is described in terms of the complete block diagram shown in Figure 3-1. Each important circuit is discussed individually.

The material in this section is organized as follows:

3-2 MEASUREMENT OF NOISE FIGURE

Noise figure is a measure of the reduction of a signal-to-noise ratio caused by the active network (receiver or amplifier) under consideration. If the network were noiseless, the signal-to-noise ratio would be unchanged by the network and the noise figure would be zero db. However, all electronic devices add noise to a signal as the signal passes through, reducing the signal-to-noise ratio. If the signal-to-noise ratio at the output of the device is half the signal-to-noise ratio at the input, noise figure is 3 db. A mathematical expression for noise figure is:

$$NF = 10 \log \left(\frac{S_i/N_i}{S_o/N_o} \right)$$

$$= 10 \log (S_i/N_i) - 10 \log (S_o/N_o)$$

Where: NF = noise figure (db)

S_i/N_i = input signal-to-noise power ratio

S_o/N_o = output signal-to-noise power ratio

In actual practice, however, it is not possible to separate the signal from the noise at the output of a receiver and measure them separately because noise is always present. Since noise is always present, output of a receiver is P_o/N_o where P_o is $S_o + N_o$. P_o is the output of the device under test when the noise source is on.

For the ⓗⓟ 347A Waveguide Noise Sources $10 \log S_i/N_i$ (excess noise) is 15.2 db; for the ⓗⓟ Models 343A VHF Noise Source and 345B IF Noise Source excess noise is 5.2 db. Model 340B measures noise figure by comparing the output of the device under test when the noise source is on (P_o), to the output of the device when the noise source is off (N_o). The comparison is made by keeping P_o constant with automatic gain control (AGC) and metering N_o.

3-3 OVER-ALL OPERATION

Operation of Model 340B Noise Figure Meter is described with reference to Figure 3-1, the complete block diagram (except for the power supply) and the waveforms in Figure 3-2.

The Switching Circuits, consisting of the 1000 cps Multivibrator, the 500 cps Binary, and the Adding Circuits, supply the gating signals to the rest of the 340B. The block diagram and waveforms are shown for automatic measurement of noise figure.

The multivibrator gates the Tuned Amplifier with a 1000 cps square-wave voltage and drives the Binary which produces a 500 cps square wave. Output from the Binary drives the Noise Source Power Supply which turns the noise source on and off at 500 cps. Waveforms 1 and 2 show that the Tuned Amplifier is gated on during the last half of the time that the noise source is on and also during the last half of the time that the noise source is off. Thus the Amplifier is not turned on until the output from the noise source has reached its maximum level or fallen to its quiescent level.

The output of the noise source is connected to the receiver being measured. The intermediate

frequency (30 or 60 mc) of this receiver is connected to the INPUT of the 340B. This signal is the output of the receiver under two conditions: 1) noise source on, 2) noise source off. The Tuned Amplifier amplifies this signal which is detected by the detector. This detector is operated over the square-law portion of its characteristic, therefore its output voltage is directly proportional to input power. Further amplification takes place in the Video Amplifier and then the zero signal level (which occurs when the Tuned Amplifier is off) is clamped by the DC Restorer. The clamped signal is shown in Figure 3-2, waveform 3. The larger amplitude pulse is the output of the Video Amplifier when both the noise source and the Tuned Amplifier are on; this output corresponds to P_o. The smaller amplitude pulse is the Video Amplifier output when the noise source is off and the Tuned Amplifier is on. The small output signal corresponds to N_o.

During the time that P_o is present at the output of the Video Amplifier the gate to the AGC Integrator is open (waveform 4) and the signal P_o is passed through the AGC Integrator. After P_o is integrated and filtered, it controls the gain of the Tuned Amplifier to keep subsequent P_o pulses at a constant amplitude.

During the time that N_o is present at the output of the Video Amplifier, the Meter Integrator Gate is open (waveform 5) and N_o is passed to the Meter Integrator and, after integration, to the meter. Since the S_i to N_i of the noise source is a known constant and since P_o is held constant by the AGC, the meter may be calibrated directly in db of noise figure.

The waveforms which operate the AGC and Meter Gates are developed in the adding circuits by adding the 1000 cps square-wave voltage from the multivibrator to the 500 cps square-wave voltages from the Binary and clipping the resultant waveforms at the appropriate voltage.

3-4 TUNED AMPLIFIER, DETECTOR, VIDEO AMPLIFIER AND DC RESTORER

The Tuned Amplifier, Detector, and Video Amplifier are shown in schematic diagram, Figure 4-7; the DC Restorer is shown in Figure 4-8.

The intermediate frequency from the receiver or amplifier being measured is connected to the INPUT of the Tuned Amplifier, amplified and passed to the Detector and Video Amplifier. The Tuned Amplifier is gated on and off at a 1000 cps rate by a square-wave voltage connected to the supressor grid of V8. Turning the Tuned Amplifier on and off establishes a zero signal level and permits measuring P_o and N_o. Since the Detector is square law, its output voltage is a direct function of input power. If the Tuned Amplifier were not turned off, the output from the Video Amplifier would be a square-wave voltage whose amplitude increased as noise figure decreased. Except for the Tuned Amplifier being gated, the Tuned Amplifier, Detector, and Video Amplifier are conventional.

Following the Video Amplifier is DC Restorer V102B, which allows the recovery of the dc value of the noise pulses even though the signal is ac coupled. V102B, shown on the Meter and Gate Circuits schematic of Figure 4-8, clamps the zero signal level (Tuned Amplifier off) to -150 volts.

3-5 SWITCHING CIRCUITS

The switching circuits consist of the 1000 cps Multivibrator, V104, the 500 cps Binary, V106, the Adding Clamp, V105. These circuits operate the Noise Source Power Supply, turn the Tuned Amplifier on and off, and separate the "source on" output from the "source off" output by opening the Meter and AGC Gates at the appropriate times.

Multivibrator, V104, free runs at a nominal rate of 1000 cps, however the rate is adjustable over a narrow range. The rate in no way affects accuracy of the ⓗⓟ 340B.

Multivibrator V104 drives V106, which produces a square-wave voltage at exactly one-half the frequency of the Multivibrator. The 1000 cps square wave from V104 is added through resistance dividers to both phases of the 500 cps square-wave voltage from V106 and clipped by V105A and B to form the Integrator Gate signals.

The negative steps of the gate signals open the integrators and allow the signals from the Video Amplifier to be separated. A signal is also taken from the 1000 cps multivibrator to gate the Tuned Amplifier, and other signals from the 500 cps Binary operate the Noise Source Power Supply.

3-6 NOISE SOURCE POWER SUPPLY

This power supply furnishes the voltages required by the Hewlett-Packard noise sources and controls the current through them. In addition, the power supply turns the noise source on and off at the correct times. Since the power requirements of waveguide noise sources (using an argon gas tube) are so different from the requirements of the temperature-limited diode type, the power supply is divided into two sections.

GAS TUBE SECTION

This supply furnishes the high ignition voltage required by the gas tube of the noise source and also controls the current passing through it.

The Gas Tube Pulser, V108, and V109, the Gas Tube Igniter, as shown in the schematic diagram, Figure 4-8, are driven by opposite phases of the 500 cycle square-wave signal from the Binary so that only one tube conducts at a time. When V108 is cut off by the signal from the Binary, the gas tube is off and the plate current from V109 goes through L101. When V108 is turned on, V109 is turned off, and L101 develops a large pulse which ignites the gas tube. Once the gas tube is ignited, the self bias of V108, set by R154 (CURRENT control) determines the gas tube current. Possibility of shock from the high voltage ignition pulse is materially reduced because the B+ connection to the supply is made through the ⓗⓟ 347A Waveguide Noise Source. Hence, the high voltage supply cannot operate unless an ⓗⓟ 347A Noise Source is connected to the instrument.

DIODE SECTION

The diode section consists of a multivibrator V110 and V111, which supplies regulated filament voltage for the diode of the noise source and a pulser to turn the noise source on and off. Output voltage of the multivibrator is controlled by varying the plate voltage of the tubes with the CURRENT control, R121. V107, the Diode Pulse, is an amplifier which biases the noise diode off by driving the filament-cathode of the diode to a high positive voltage. Setting the NOISE SOURCE switch to DIODE connects the Diode Pulser to the output jack J103.

3-7 AGC GATE AND INTEGRATOR

The AGC Gate V103A and Integrator V101A are shown in the schematic diagram, Figure 4-5. R106 is common to both cathode circuits and the voltage drop across it biases V101A well into cutoff as long as V103A conducts. When both the Tuned Amplifier and noise source are on, the gate signal from the Switching Circuits biases V103A into cutoff permitting conduction through V101A. Since the video signal connected to V101A is clamped by the DC Restorer to -150 volts, the average current through V101A depends on the amplitude of the signal at the input of the 340B. The negative voltage developed at the plate of V101A is thoroughly filtered and returned to the first three stages of the Tuned Amplifier. In this way the gain of the Tuned Amplifier is controlled to keep its output constant when the noise source is on (P_O), so that the amplitude of N_O is a function of noise figure.

R103 in the plate circuit of V101A is a fine adjustment on the AGC voltage which controls the gain of the Tuned Amplifier. This control calibrates full scale for any particular set of input conditions. Setting the METER FUNCTION switch to INF turns the noise source on each time the Tuned Amplifier is gated on, thus, the pulses which go to the Meter Integrator are the same amplitude as those which go to the AGC Integrator. This condition corresponds to $N_O = P_O$, or a noise figure of infinity. Then R103 is adjusted for a noise figure meter reading of infinity when the METER FUNCTION switch is set to INF.

3-8 METER GATE AND INTEGRATOR

As can be seen from the schematic diagram, Figure 4-5, this circuit differs only slightly from the AGC Gate and Integrator. Except for the timing, the operation of the two circuits is the same. The gate signal from the Switching Circuits cuts off V103B, allowing V101B to conduct only when the Tuned Amplifier is on and the noise source is off. Since the signal applied to the grid of V101B is the clamped video signal from the DC Restorer, the average current through V101B increases as the pulse, N_O, gated through the Meter Integrator, increases in amplitude. This current is read on the meter which is calibrated in noise figure.

Setting the METER FUNCTION switch to ZERO supplies a zero noise condition to the grid of the Meter Integrator. Then R109 may be adjusted to bring the plate voltage of V101B to ground so there is no current through the meter.

3-9 MANUAL OPERATION

In manual operation the opposite phase from the Binary drives the Noise Source Power Supply so that the noise source is turned on one-half millisecond before the meter integrator is turned on. Also, the AGC voltage is grounded so that the full gain of the Gated Amplifier is present. Because of the square-law detector, meter deflection is proportional to input power. Thus, the 340B becomes a sensitive detector which is accurately square law over the upper three-fourths of the meter scale. Relative power measurements should not be made below one-fourth scale because the DC Restorer does not clamp well at low signal levels. This is not a problem during automatic measurements, because alternate pulses are large in amplitude and the DC Restorer clamps effectively.

SECTION IV
MAINTENANCE

4-1 INTRODUCTION

This section contains necessary maintenance, adjustment, and repair information.

The material is arranged as follows:

4-2 CABINET REMOVAL

1) Remove the four screws which secure the rear cover and remove the rear cover.

2) Place the 340B on its back.

3) Unscrew the two recessed screws about 1/4" which are under the front panel.

4) Lift the cabinet toward the top to the instrument and off.

4-3 CONNECTION FOR 230 VOLT OPERATION

To connect this instrument for 230 volt operation remove the two wire jumpers from the terminal strip to which the power cord is attached. Install a new jumper to connect the green-black wire to the black-yellow wire.

When connection for 230 volt operation is made, change the line fuse to a 2ampere slow-blow type.

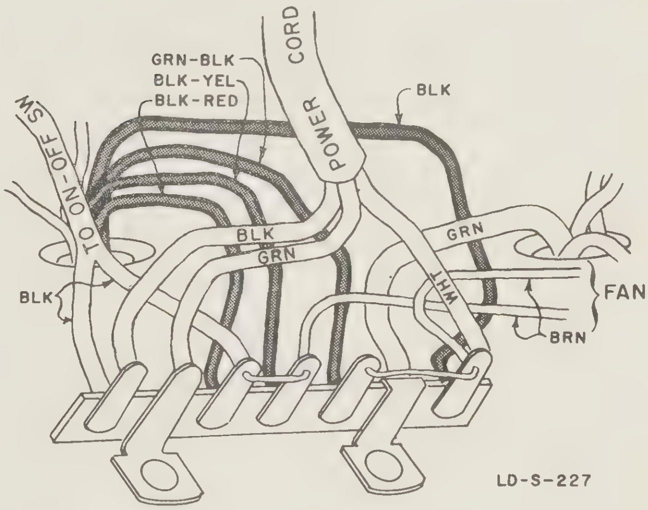
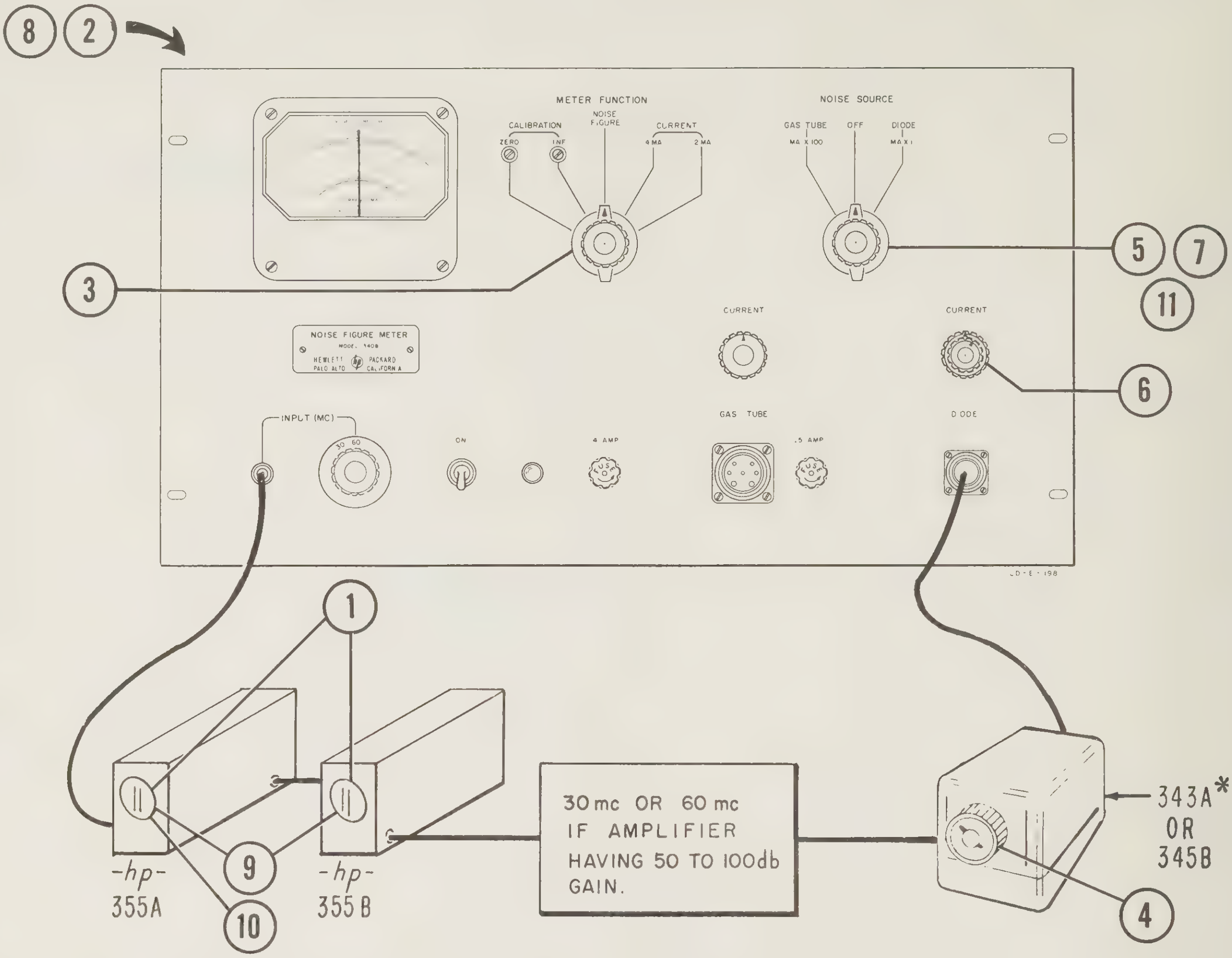


Figure 4-1. Transformer Connection

4-4 OVER-ALL PERFORMANCE CHECK

Over-all operation can easily be checked whenever desired by comparing an automatic measurement with a "twice power" measurement.

In a "twice power" measurement the 340B is used only as a sensitive power monitor which can cause no error since power into it is kept constant. Figures 4-2 and 4-3 give the procedures for an over-all performance check using the 345B and a 347A noise source respectively.



1. Connect equipment as shown above, set both attenuators to zero, and set the INPUT switch and 345B switch to IF amplifier frequency.
2. Set NOISE FIGURE switch (back of instrument) to AUTO.
3. Adjust zero, inf. then set to NOISE FIGURE.
4. Set to match input impedance (when using the ⓗ 345B).
5. Set to DIODE.
6. Set for 7.5 db on the meter diode scale.
7. Turn to OFF.
8. Set NOISE FIGURE switch to MANUAL.
9. Adjust attenuators for a reference reading near mid-scale on the lower current scale. This reading is I_1.
10. Add 2 db.
11. Turn to DIODE. Read I_2 on lower current scale. I_2 should equal I_1.
12. If $\frac{I_1 - I_2}{I_1}$ is ±0.05 or less, the 340 is operating within specifications.

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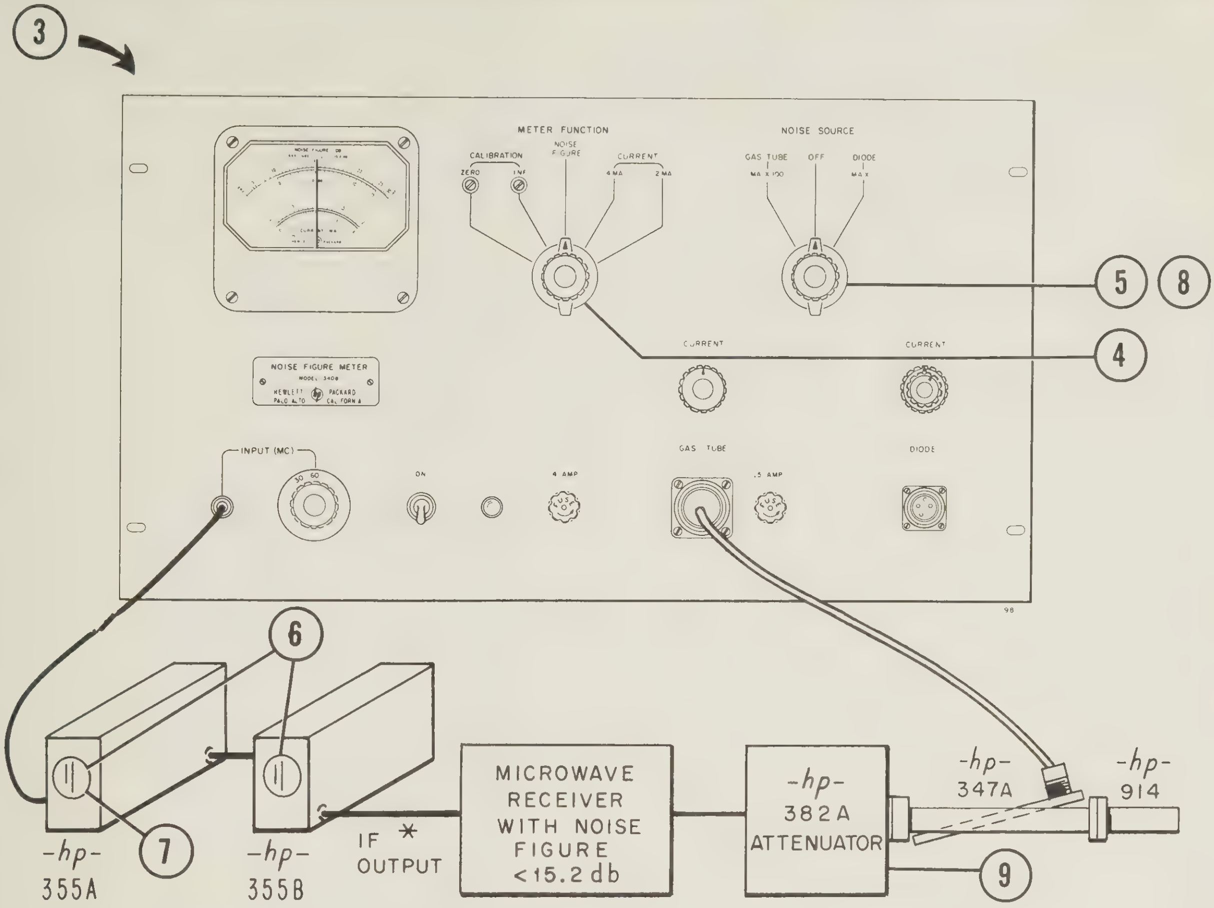
* If ⓗ 343A is used, the input impedance of the IF Amplifier must match the source impedance of the 343A which is 50 ohms.

** Correct for impedance mismatch if IF Amplifier output is other than 50 ohms and the 355B is set for less than 20 db.

Figure 4-2. Performance Check Using ⓗ Diode Noise Source



1. Measure Noise Figure as shown in Figure 2-5.
2. Connect equipment as shown above. Set all attenuators to zero.
3. Turn NOISE FIGURE switch (rear of 340B) to MANUAL.
4. Set to NOISE FIGURE.
5. Set to OFF.
6. Adjust attenuator for convenient reference reading > 1/4 scale.
7. Add 3 db attenuation. *
8. Turn to GAS TUBE.
9. Adjust 382A for reference reading of step 6.
10. NF = 15.2 db - total insertion loss of 382A.
11. Step 1 and step 10 should agree within the specified accuracy of the 340B ±accuracy ⓗⓟ 382A and ⓗⓟ 355A.

* Correct for impedance mismatch if Receiver IF Amplifier output is other than 50 ohms and 355B is set for less than 20 db.

Figure 4-3. Performance Check Using ⓗⓟ 347A Waveguide Noise Source

4-5 TUBE REPLACEMENTS

The following Table 4-1 lists the vacuum tubes by circuit reference number, and indicates necessary adjustments.

Table 4-1. Tube Replacement

Tube	Adjustment or Check Required
V1-4	Adjust +250 v regulated (par. 4-6B)
V5	Measure -150 v ±5 v. Vary line voltage ±10%, change of voltage should be less than ±1 v
V6-10	Re-tune coils on each side of tube replaced, (par. 4-6C)
V101, V102	Adjust filament voltage (par. 4-6A) and check ZERO and INF for proper operation
V103	Check operation of AGC (par. 4-6D)
V104	Measure plate waveform, peak-to-peak amplitude = 175 v ±20% (140 v to 210 v)
V105	No check required if instrument operates
V106	Measure plate waveform, peak-to-peak amplitude = 185 v ±20% (148 v to 222 v)
V107	Check diode current range (par. 2-2D)
V108, V109	Connect a 250 ma 347A Waveguide Noise Source (preferably an S347A) and check that maximum current is at least 250 ma at 103 volt line
V110, V111	Check DIODE CURRENT ADJ. (par. 2-2D) and regulation. 10% change of line voltage should not change diode current more than 5%. (±0.15 ma at 3 ma)

Tubes with standard EIA (JEDEC) characteristics can be used for replacement. In a great number of cases, instrument malfunction can be traced to a defective or weak tube. Check tubes by substitution and replace only those proven to be weak or defective. Mark original tubes to insure their being returned to the same socket if not replaced. Results obtained by the use of a "tube checker" can be erroneous and misleading.

You are urged to check tubes before changing any internal control settings. Adjustments that are made in an attempt to compensate for a defective tube or circuit component will often complicate a repair problem. You can usually save time and avoid a complete instrument recalibration by repairing an instrument without changing any of the internal adjustments.

4-6 ADJUSTMENTS

Model 340B has few adjustments which cannot be made from the front panel. These adjustments affect only the power supply and the tuning of the Amplifier.

The specifications for the 340B are given in the front of this manual. The following test procedure contains extra checks to help you to analyze a particular instrument. This additional data should not be considered as specifications.

A. FIL ADJ. R4

1) Connect an ac voltmeter between pins 2 and 4 of the ballast tube, RT1. (Pin 4 is used as a tie-point for -150 v).

CAUTION

These points are -150 volts from ground, so the meter used must be isolated from the 340B chassis and from the power line ground.

2) Adjust R4 for 6.3 v rms.

3) Vary line voltage from 103 to 127 volts. The meter reading should not vary more than 0.2 volt from 6.3 volts.

B. +250 VDC ADJ. R16

1) Connect a dc voltmeter between chassis and cathode (pin 6) of V2.

2) Adjust R16 for +250v ±5 v.

3) Vary line voltage from 103 to 127 volts. The meter reading should not vary more than ±1 volt.

C. TUNING THE AMPLIFIER COILS

Set line voltage to 103 volts. Connect an ⓗⓟ Model 606A HF Signal Generator (or equivalent) to the 340B INPUT and set the output frequency of the Model 606A to 30 mc.

Set 606A to CW. Adjust the output level of the 606A for a set level reading on its output meter. Turn 340B INF potentiometer to clockwise end of control and set METER FUNCTION to NOISE FIGURE.

Peak all 30 mc coils for maximum 340B meter reading, decreasing the signal from the 606A with its output attenuator if the 340B meter pins. Repeat peaking adjustment.

After the coils are tuned, the sensitivity for a full scale reading should be at least -60 dbm. An open coil or a dead tube will cause a 15 to 20 db loss. If the 340B meter remains at full scale with no input signal, then a spurious oscillation exists.

Repeat the above adjustments at 60 mc, adjusting the 60 mc coils.

Note, that the amplifier coils are tuned at low line voltage. In this manner gain changes due to heater voltage (within the specified operating range of the instrument) are neutralized by the slight detuning due to the Miller effect.

D. CHECKING AGC ACTION

1) Set line voltage to 115 volts.

2) Connect a 30 mc CW signal from an ℏ Model 606A to 340B INPUT.

3) Set Model 606A output to -10 dbm and adjust INF potentiometer for a 30 db reading on the 340B meter.

4) Vary Model 606A output from -10 to -60 dbm; the meter pointer should remain between 27-1/2 and inf.

E. BINARY OUTPUT

These terminals, J105, are located inside the instrument on the main deck. The signal appearing at this point is the output from the binary tube, V106 (12AU7). The waveshape and amplitude may be compared to that indicated in the schematic diagram. The amplitude normally will be within ±20% of the stated values. This check will verify that the multivibrator and binary circuits are operating correctly.

4-7 CHECKING METER TRACKING

To check the 340B meter scale calibration, it is only necessary to setup series of pulses in synchronism with the binary output and means of adjusting a precisely known power ratio between two pulses, N_1, noise source off, and N_2, noise source on. Equipment required for this check is as follows:

1) A square-wave generator which can be externally synchronized, such as an ℏ Model 211A; 2) a stable vhf signal generator, such as an ℏ Model 606A; 3) a vhf attenuator calibrated to ±0.1 db in 1 db steps from 1 to 11 db, such as an ℏ Model 355A (typical accuracy of 355A at 30 mc is approximately 0.06 db); 4) a crystal detector, such as an ℏ Model 420A; and 5) an oscilloscope with a high sensitivity of 1 millivolt/cm, such as an ℏ Model 130B. Equipment connection is shown in Figure 4-4.

The 340B binary output jack (three terminals binding posts) located inside the instrument on the top of the chassis provides a synchronizing signal for the 211A Square Wave Generator. Either terminal A or B may be used and the correct terminal to be used is given in the procedure below. The negative-going half of square wave from 211A 600 ohms output is fed into the modulation input of 606A to provide a negative-going amplitude modulation during the time for which the N_1 pulse (noise source off) is being sampled in the 340B. The positive-going half of the square wave from 211A represents the time of the N_2 pulse (noise source on). The depth of the modulation of the N_1 simulated pulse is adjusted by output amplitude control on the 211A. This gives a fine control on the amount of difference between the N_1 and N_2 pulses. The pulse ratio of N_1 to N_2 must be set very accurately in the procedure given below, as shown in figure 4-5, which plots the 340B scale calibration in terms of the pulse ratio between N_1 and N_2. The curve is derived from the equation

$$NF_{db} = 15.2 - 10 \log_{10} \left(\frac{N_2}{N_1} - 1\right)$$

(See NOTE, Sect II Page 13)

Note that a ±0.1 db inaccuracy in the setting of the N_2 to N_1 pulse ratio at a 3 db setting, which is the center of the scale, is equivalent to a ±0.25 db inaccuracy on the 340B scale reading, and since the overall specification on the meter reading in the center of the range is ±0.5 db it is important that the pulse ratio be accurately set.

Following is a step-by-step procedure for calibrating the 340B at 30 mc and -60 dbm. Other calibrations may similarly be done up to 65 mc and -20 dbm for full performance check.

1) Remove the rear cover of 340B. Connect equipment as shown in Figure 4-4; turn on equipment and allow warm up period of 30 minutes.

2) Set controls as follows:

211A Square Wave Generator. FREQUENCY dial on "4.25", RANGE switch to X100, SYMMETRY control to mid-position, and 600 Ω OUTPUT AMPLITUDE control to "0".

606A HF Signal Generator, FREQUENCY to 30 MC,

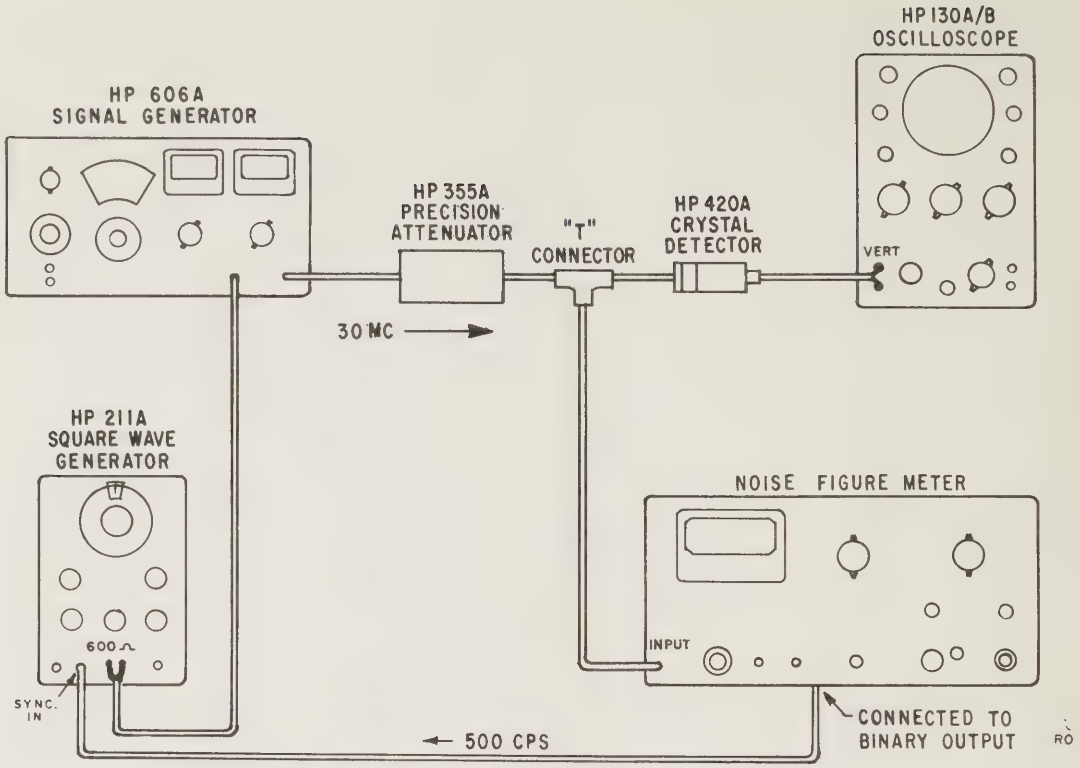


Figure 4-4. Test Setup for Meter Tracking

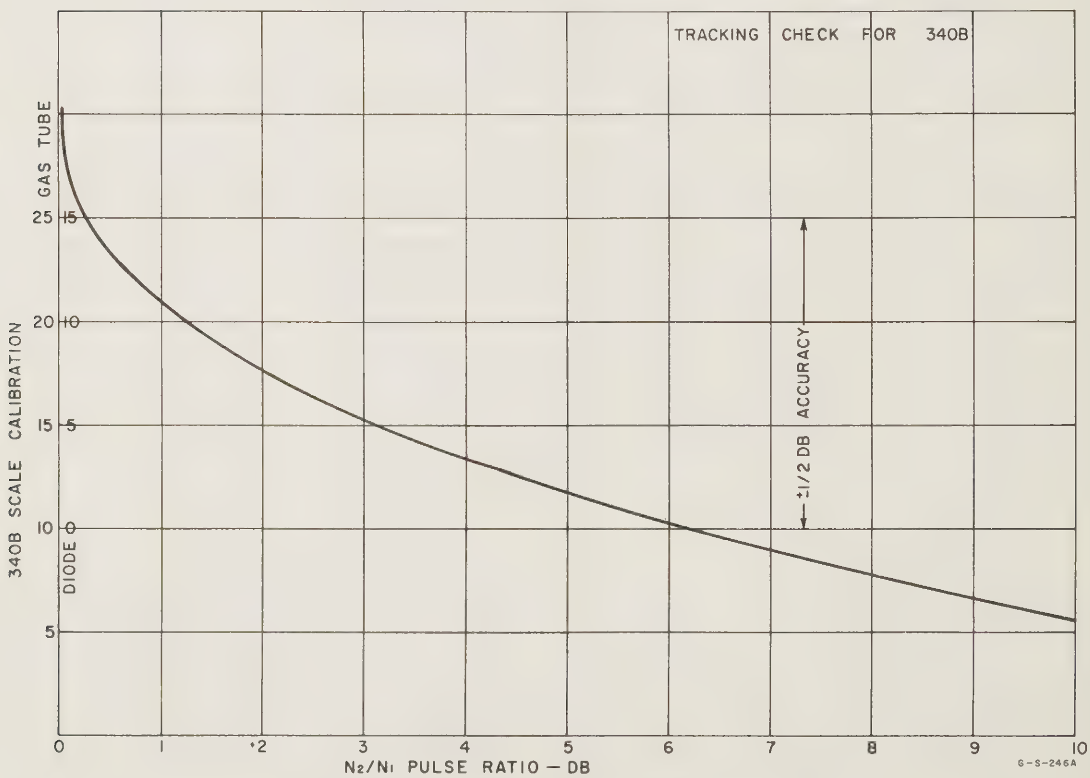


Figure 4-5. Scale Calibration vs Pulse Ratio

MODULATION SELECTOR switch to EXT. DC, MODULATION AMPLITUDE control to mid-position, ATTENUATOR to -60 DBM, and output VERNIER control to set meter pointer of power monitor meter exactly on "0" DBM.

355A VHF Coaxial Attenuator. Set for 1 db of attenuation.

130B Oscilloscope. VERT. SENSITIVITY switch to 10 MILLIVOLTS/CM, VERT. AC-DC switch to DC SWEEP TIME/CM switch to .2 MILLISECOND/CM, HORIZ. SENSITIVITY switch to X1 INT. SWEEP, TRIGGER SLOPE switch to "-", and SYNC selector switch to INT.

340B Noise Figure Meter. INPUT switch to 30 MC, METER FUNCTION to NOISE FIGURE, NOISE SOURCE to OFF, and NOISE FIGURE switch (located at rear of instrument) to AUTO.

3) Disconnect cable from 606A MODULATION INPUT-OUTPUT connector. On 340B, turn METER FUNCTION switch to CALIBRATION ZERO and adjust zero set; turn METER FUNCTION to CALIBRATION INF. and adjust infinity set.

4) Turn METER FUNCTION switch to NOISE FIGURE and reconnect modulation input cable.

5) Slowly advance the setting of 211A 600 Ω OUTPUT AMPLITUDE control. As 211A output amplitude is increased, the meter pointer of 340B meter should move down-scale (left) from INF. marking towards "5" on the upper scale. If the pointer begins to move up-scale (right) from INF. marking, change 340B binary output connection to the other binding posts.

6) Turn 211A SYMMETRY control slowly to counterclockwise position and note any changes in the meter reading of 340B. If the reading changes then turn SYMMETRY control in the opposite direction and note any changes in the meter reading. The correct setting of 211A SYMMETRY control is when there are no changes noted in the meter reading.

7) Set 606A ATTENUATOR to 0 DBM; adjust 355A for 11 db of attenuation, and note the position of N_1 and N_2 pulses on the oscilloscope (see Fig. 4-6).

8) Turn 130B VERT. SENSITIVITY switch to 1 MILLIVOLT/CM; adjust VERT. POS. control to align the trailing edge of N_2 pulse with center line of graticule (see Figure 4-6).

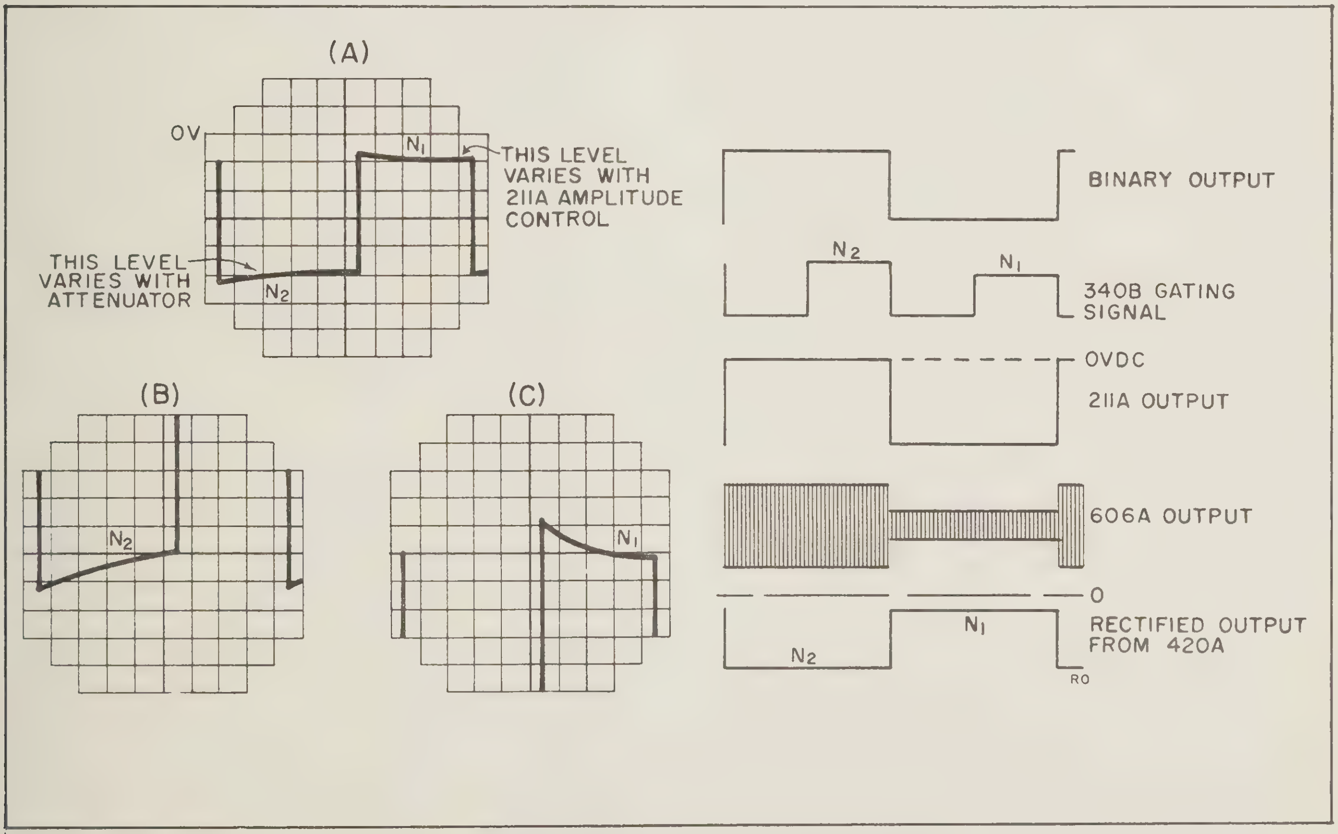


Figure 4-6. Waveforms

9) Adjust 355A for 1 db of attenuation; adjust 211A 600 Ω OUTPUT AMPLITUDE to align trailing edge of N_1 pulse with center line of graticule. Do not change the setting of 130B VERT. POS. and VERT. SENSITIVITY during this adjustment.

10) Set 606A ATTENUATOR to -60 DBM and record the reading on 340B meter.

11) Repeat the procedure given in steps 8, 9, 10, and 11 using 10 db and 1 db attenuation in 355A for ratio N_2/N_1 of 9 db; using 9 and 1 db attenuation for ratio N_2/N_1 of 8 db, etc. At ratios below 4 or 5 db, it may be necessary to decrease the sensitivity of 130B to align N_2 pulse level.

12) Compare the indicated noise figure with computed noise figure given below:

Ratio	Computed noise figure
10 db	5.66
9 db	6.79
8 db	7.95
7 db	9.18
6 db	10.45
5 db	11.85
4 db	13.40
3 db	15.22
2 db	17.54
1 db	21.07
0 db	INF

The computed Noise Figure is obtained from the following equation:

$$\text{NF db} = 15.2 - 10 \log_{10} \left(\frac{N_2}{N_1} - 1 \right)$$

and substituting N_2/N_1 from 0 to 10 db. (See NOTE, Sect II Page 13.)

4-8 TROUBLE LOCALIZATION

Most failures in the 340B will be due to defective electron tubes. Use Table 4-2 to help localize a trouble. Compare voltages and waveforms in the unit to those shown on the schematic diagram to find the trouble.

Table 4-2. Trouble Localization

Symptom	Possible Cause
Line fuse blows	Shorted CR2, 3, 4 or 5
Line fuse blows when gas tube is turned on	Short in cable or gas tube mount. Broken gas tube in noise source. Shorted L101
Gas tube won't ignite	Defective V108, 109 or tube in 347A. Open gas tube power cable. Blown 0.5 amp fuse
Insufficient gas tube current	Defective V106, 108 or gas tube in 347A noise source
Meter zero varies with line voltage	+250 volt supply not regulating. Defective V1, 2, 3, 4
15-20 db gain loss in Tuned Amplifier	Defective tube in Tuned Amplifier. Open coil in Tuned Amplifier
Meter pins with no input to 340B	Oscillations in Tuned Amplifier
Meter pins with usual input	No AGC. Check position of Noise Figure switch

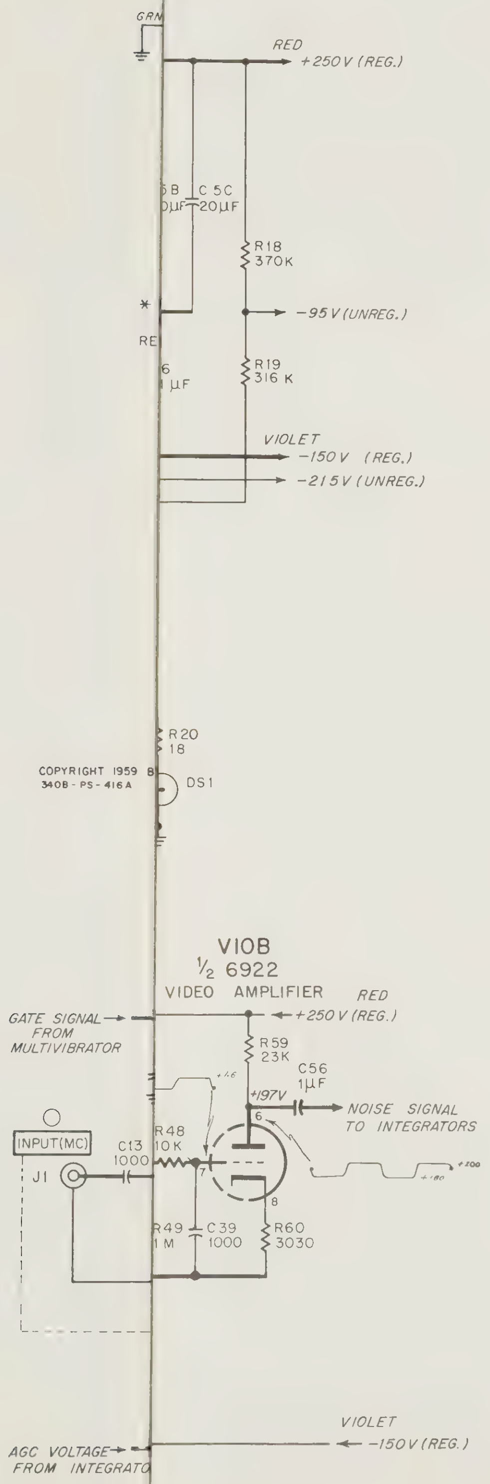


Figure 4-7. Power Supply and Tuned Amplifier

9) Adjust 355A for 1 db of attenuation; adjust 211A 600 Ω OUTPUT AMPLITUDE to align trailing edge of N_1 pulse with center line of graticule. Do not change the setting of 130B VERT. POS. and VERT. SENSITIVITY during this adjustment.

10) Set 606A ATTENUATOR to -60 DBM and record the reading on 340B meter.

11) Repeat the procedure given in steps 8, 9, 10, and 11 using 10 db and 1 db attenuation in 355A for ratio N_2/N_1 of 9 db; using 9 and 1 db attenuation for ratio N_2/N_1 of 8 db, etc. At ratios below 4 or 5 db, it may be necessary to decrease the sensitivity of 130B to align N_2 pulse level.

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6 db	10.45
5 db	11.85
4 db	13.40
3 db	15.22
2 db	17.54
1 db	21.07
0 db	INF

The computed Noise Figure is obtained from the following equation:

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and substituting N_2/N_1 from 0 to 10 db. (See NOTE, Sect II Page 13.)

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Insufficient gas tube current	Defective V106, 108 or gas tube in 347A noise source
Meter zero varies with line voltage	+250 volt supply not regulating. Defective V1, 2, 3, 4
15-20 db gain loss in Tuned Amplifier	Defective tube in Tuned Amplifier. Open coil in Tuned Amplifier
Meter pins with no input to 340B	Oscillations in Tuned Amplifier
Meter pins with usual input	No AGC. Check position of Noise Figure switch

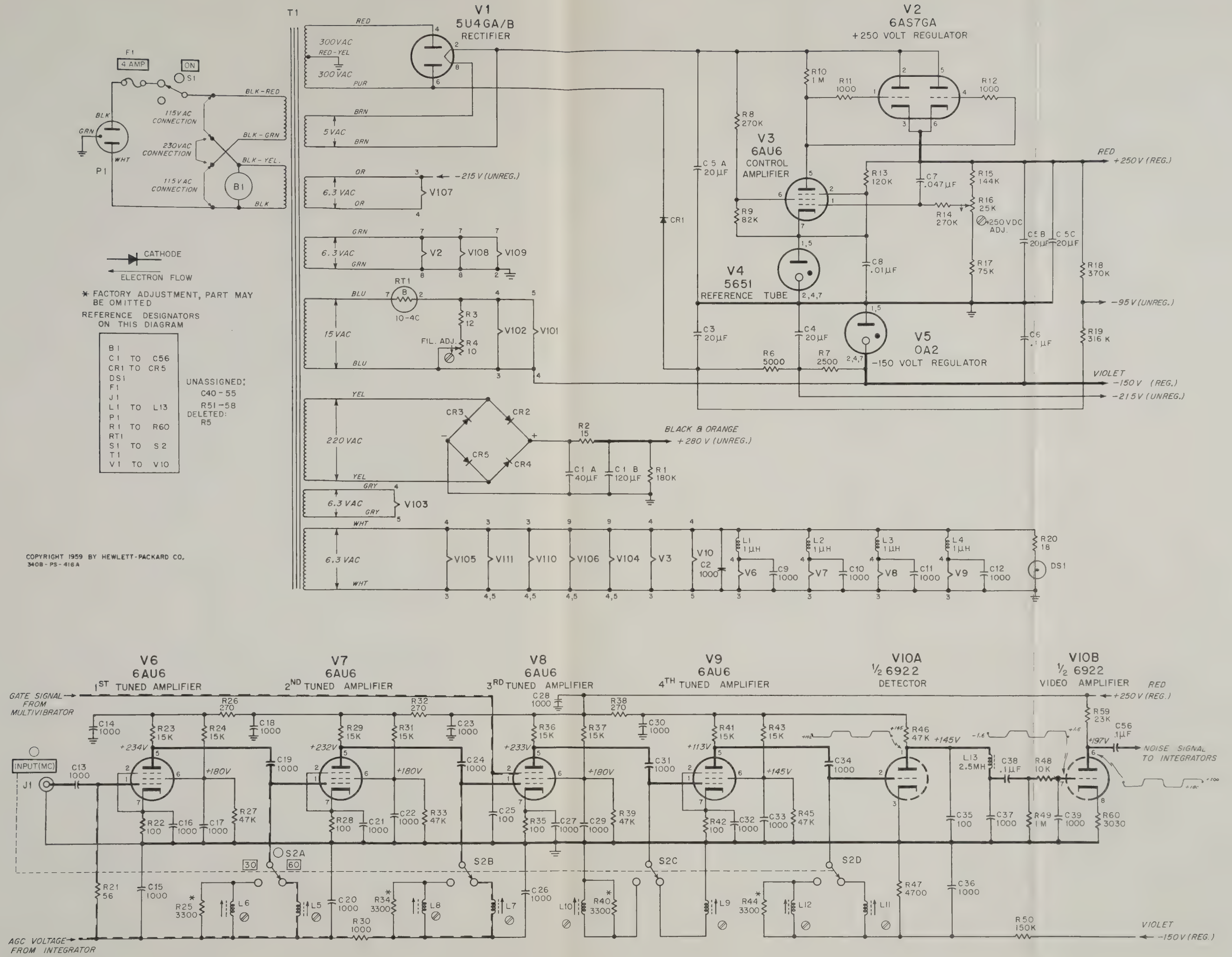

Figure 4-7. Power Supply and Tuned Amplifier

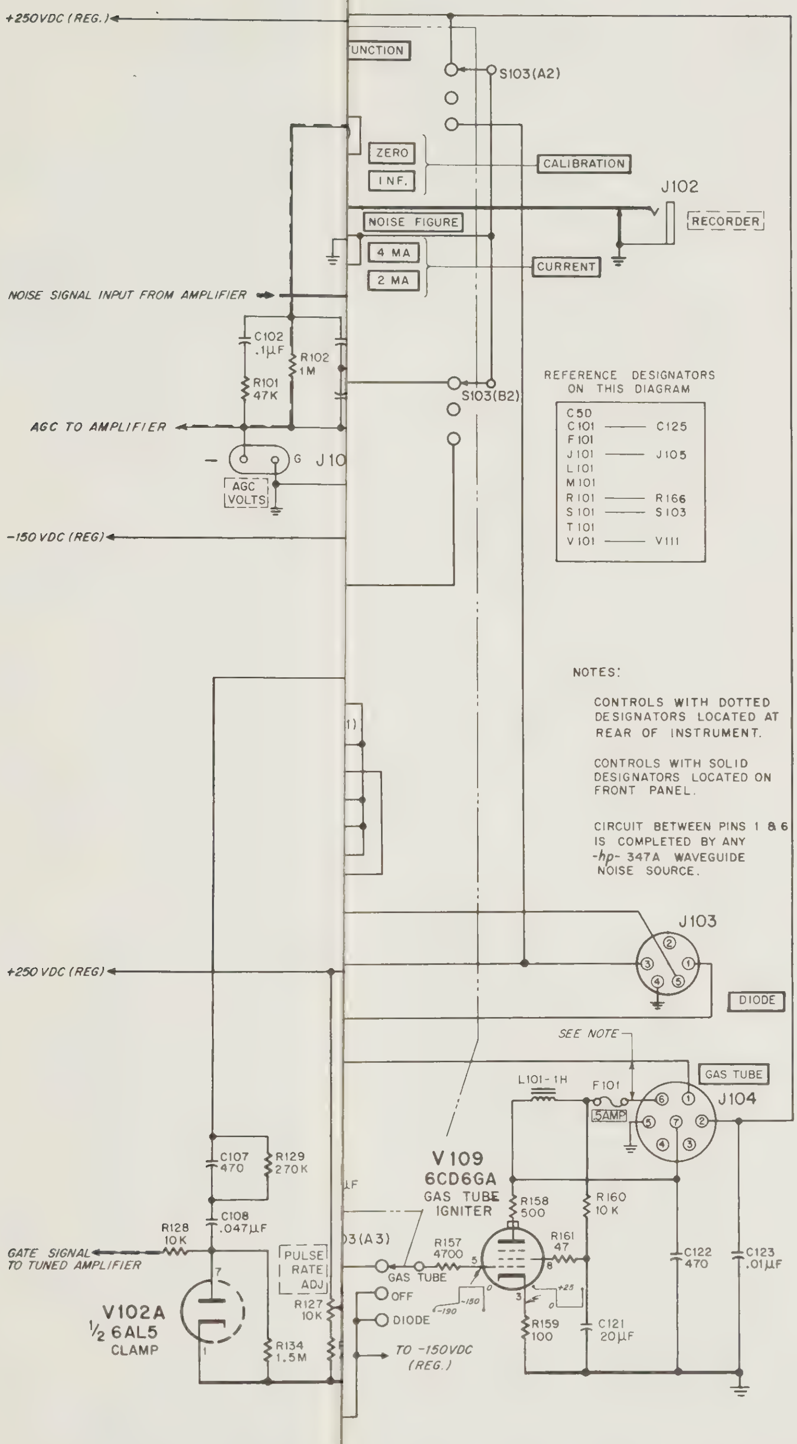

Figure 4-8. Meter and Timing Circuit

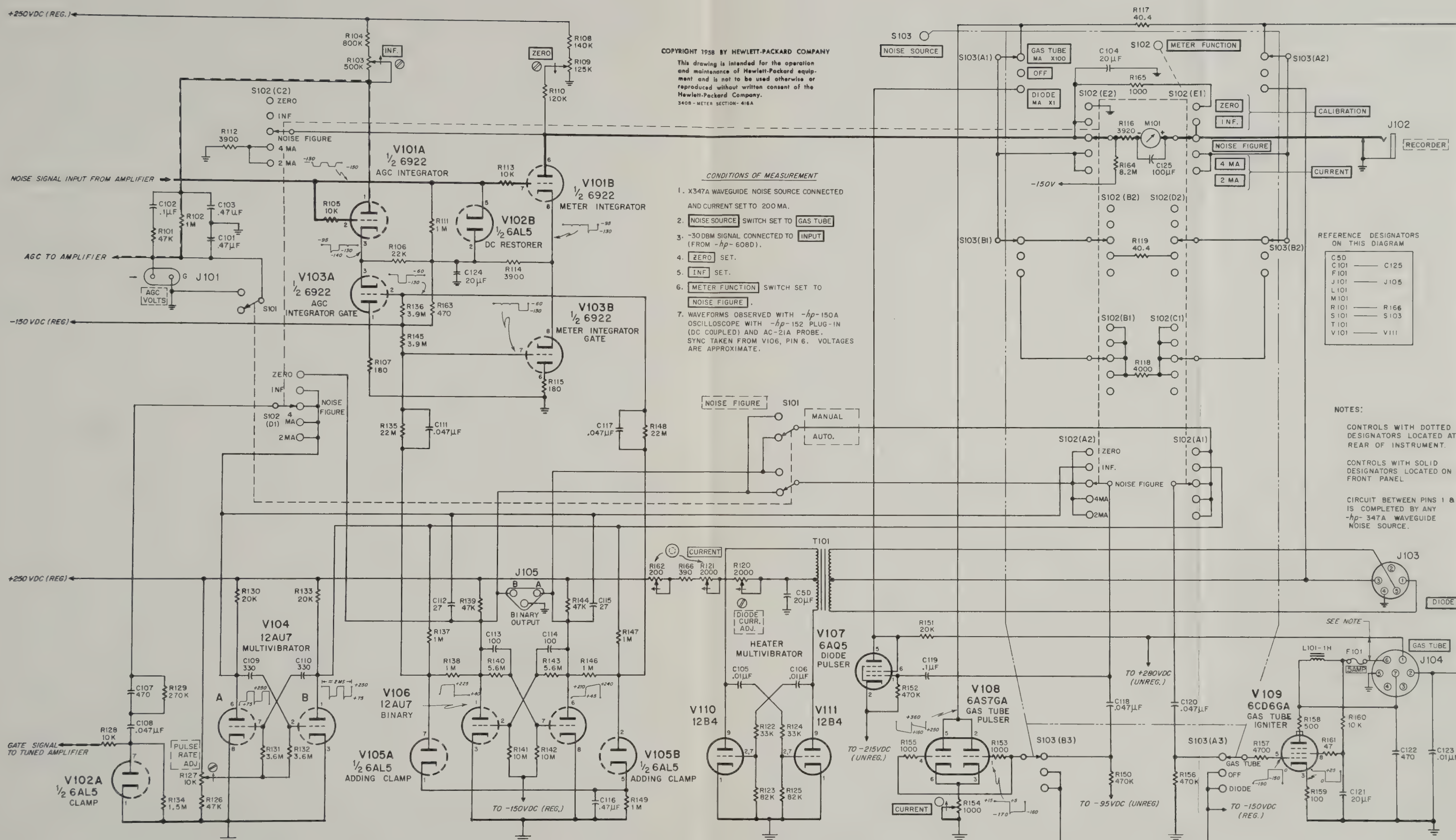

Figure 4-8. Meter and Timing Circuit

SECTION V
REPLACEABLE PARTS

5-1 INTRODUCTION

This section contains information for ordering replacement parts for the Model 340B Noise Figure Meter.

Table 5-1 lists replaceable parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designation. Other entries applying to an identical part refer to the first designation. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

1) Reference designator.

2) Full description of the part.

3) Manufacturer of the part in a five-digit code; see list of manufacturers, Table 5-3.

4) Hewlett-Packard stock number.

5) Total quantity used in the instrument (TQ col).

5-2 ORDERING INFORMATION

To order a replacement part, address order or inquiry to your nearest Hewlett-Packard field office (see lists at the rear of this manual).

Specify the following information for each part:

1) Model and complete serial number of instrument.

2) Hewlett-Packard stock number.

3) Circuit reference designation.

4) Description.

To order a part not listed in Table 5-1, give a complete description of the part and include its function and location

REFERENCE DESIGNATORS

A = assembly
B = motor
BT = battery
C = capacitor
CP = coupler
CR = diode
DL = delay line
DS = device signaling (lamp)
E = misc electronic part
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter
MP = mechanical part
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer
TB = terminal board
TP = test point
V = vacuum, tube, neon bulb, photocell, etc.
W = cable
X = socket
Y = crystal

ABBREVIATIONS

A = amperes
A. F. C. = automatic frequency control
AMPL = amplifier

B. F. O. = beat frequency oscillator
BE CU = beryllium copper
BH = binder head
BP = bandpass
BRS = brass
BWO = backward wave oscillator

CCW = counter-clockwise
CER = ceramic
CMO = cabinet mount only
COEF = coefficient
COM = common
COMP = composition
CONN = connector
CP = cadmium plate
CRT = cathode-ray tube
CW = clockwise

DEPC = deposited carbon
DR = drive

ELECT = electrolytic
ENCAP = encapsulated
EXT = external

F = farads
FH = flat head
FIL H = fillister head
FXD = fixed

GE = germanium
GL = glass
GRD = ground(ed)

H = henries
HEX = hexagonal
HG = mercury
HR = hour(s)

IF = intermediate freq
IMPG = impregnated
INCD = incandescent
INCL = include(s)
INS = insulation(ed)
INT = internal

K = kilo = 1000

LIN = linear taper
LK WASH = lock washer
LOG = logarithmic taper
LPF = low pass filter

M = milli = 10^{-3}
MEG = meg = 10^{6}
MET FLM = metal film
MET OX = metallic oxide
MFR = manufacturer
MINAT = miniature
MOM = momentary
MTG = mounting
MY = "mylar"

N = nano (10^{-9})

N/C = normally closed
NE = neon
NI PL = nickel plate
N/O = normally open
NPO = negative positive zero (zero temperature coefficient)
NRFR = not recommended for field replacement
NSR = not separately replaceable

OBD = order by description
OH = oval head
OX = oxide

P = peak
PC = printed circuit
PF = picofarads = 10^{-12} farads
PH BRZ = phosphor bronze
PHL = Phillips
PIV = peak inverse voltage
P/O = part of
POLY = polystyrene
PORC = porcelain
POS = position(s)
POT = potentiometer
PP = peak-to-peak
PT = point
PWV = peak working voltage
RECT = rectifier
RF = radio frequency
RH = round head
RIV = reverse inverse voltage

RMO = rack mount only
RMS = root-mean square
RWV = reverse working voltage
S-B = slow-blow
SCR = screw
SE = selenium
SECT = section(s)
SEMICON = semiconductor
SI = silicon
SIL = silver
SL = slide
SPL = special
SST = stainless steel
SR = split ring
STL = steel

TA = tantalum
TD = time delay
TGL = toggle
TI = titanium
TOL = tolerance
TRIM = trimmer
TWT = traveling wave tube
U = micro = 10^{-6}
VAR = variable
VDCW = dc working volts

W/ = with
W = watts
WIV = working inverse voltage
WW = wirewound
W/O = without

01194-11

Table 5-1. Reference Designation Index

Reference Designation	ⓗ Stock No.	Description #	Note
B1	3140-0010	MOTOR:AC 1/175 HP 2800 RPM	
B1	3160-0011	BLADE:FAN 5 BLADES, 5-1/2 DIA RACK MODEL	
B1	3160-0012	BLADE:FAN 5 BLADES 5-1/2 DIA CABINET MODEL	
B1	3150-0004	FL:AIR 7 IN X 7 IN X 1/2 IN RACK MODEL	
C1	0180-0030	C:FXD ELECT 120-40 UF 450VDCW	
C2	0150-0050	C:FXD CER 1000PF 600 VDCW	
C3	0180-0011	C:FXD ELECT 20UF 450VDCW	
C4	0180-0011	C:FXD ELECT 20UF 450VDCW	
C5	0180-0025	C:FXD ELECT 4 SECT 20UF 450VDCW	
C6	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C7	0160-0005	C:FXD MY 0.047UF 10% 600VDCW	
C8	0160-0002	C:FXD MY .01UF 10% 600VDCW	
C9	0150-0050	C:FXD CER 1000PF 600 VDCW	
C10	0150-0050	C:FXD CER 1000PF 600 VDCW	
C11	0150-0050	C:FXD CER 1000PF 600 VDCW	
C12	0150-0050	C:FXD CER 1000PF 600 VDCW	
C13	0150-0050	C:FXD CER 1000PF 600 VDCW	
C14	0150-0050	C:FXD CER 1000PF 600 VDCW	
C15	0150-0050	C:FXD CER 1000PF 600 VDCW	
C16	0150-0050	C:FXD CER 1000PF 600 VDCW	
C17	0150-0050	C:FXD CER 1000PF 600 VDCW	
C18	0150-0050	C:FXD CER 1000PF 600 VDCW	
C19	0150-0050	C:FXD CER 1000PF 600 VDCW	
C20	0150-0050	C:FXD CER 1000PF 600 VDCW	
C21	0150-0050	C:FXD CER 1000PF 600 VDCW	
C22	0150-0050	C:FXD CER 1000PF 600 VDCW	
C23	0150-0050	C:FXD CER 1000PF 600 VDCW	
C24	0150-0050	C:FXD CER 1000PF 600 VDCW	
C25	0150-0051	C:FXD CER 100 PF 600 VDCW	
C26	0150-0050	C:FXD CER 1000PF 600 VDCW	
C27	0150-0050	C:FXD CER 1000PF 600 VDCW	
C28	0150-0050	C:FXD CER 1000PF 600 VDCW	
C29	0150-0050	C:FXD CER 1000PF 600 VDCW	
C30	0150-0050	C:FXD CER 1000PF 600 VDCW	
C31	0150-0050	C:FXD CER 1000PF 600 VDCW	
C32	0150-0050	C:FXD CER 1000PF 600 VDCW	
C33	0150-0050	C:FXD CER 1000PF 600 VDCW	
C34	0150-0050	C:FXD CER 1000PF 600 VDCW	
C35	0150-0051	C:FXD CER 100 PF 600 VDCW	
C36	0150-0050	C:FXD CER 1000PF 600 VDCW	
C37	0150-0050	C:FXD CER 1000PF 600 VDCW	
C38	0170-0022	C:FXD MY 0.1UF 20% 600VDCW	
C39	0150-0050	C:FXD CER 1000PF 600 VDCW	
C40 THRU C55		NOT ASSIGNED	
C56	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C57 THRU C100		NOT ASSIGNED	

See list of abbreviations in introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description #	Note
C101	0160-0015	C:FXD PAPER 0.47UF 10% 200VDCW	
C102	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C103	0160-0015	C:FXD PAPER 0.47UF 10% 200VDCW	
C104	0180-0045	C:FXD ELECT 20UF 25VDCW	
C105	0160-0002	C:FXD MY .01UF 10% 600VDCW	
C106	0160-0002	C:FXD MY .01UF 10% 600VDCW	
C107	0140-0049	C:FXD MICA 68 PF 5% 500 VDCW	
C108	0160-0005	C:FXD MY 0.047UF 10% 600VDCW	
C109	0140-0168	C:FXD MICA SIL 330 PF 5% 300 VDCW	
C110	0140-0168	C:FXD MICA SIL 330 PF 5% 300 VDCW	
C111	0160-0005	C:FXD MY 0.047UF 10% 600VDCW	
C112	0140-0005	C:FXD MICA 27 PF 10% 500VDCW	
C113	0140-0054	C:FXD MICA 100 PF 10% 500 VDCW	
C114	0140-0054	C:FXD MICA 100 PF 10% 500 VDCW	
C115	0140-0005	C:FXD MICA 27 PF 10% 500VDCW	
C116	0160-0015	C:FXD PAPER 0.47UF 10% 200VDCW	
C117	0160-0005	C:FXD MY 0.047UF 10% 600VDCW	
C118	0160-0005	C:FXD MY 0.047UF 10% 600VDCW	
C119	0160-0001	C:FXD MY 0.1UF 10% 600VDCW	
C120	0160-0005	C:FXD MY 0.047UF 10% 600VDCW	
C121	0180-0011	C:FXD ELECT 20UF 450VDCW	
C122	0160-0059	C:FXD PAPER 470PF 20% 6000VDCW	
C123	0160-0002	C:FXD MY .01UF 10% 600VDCW	
C124	0180-0011	C:FXD ELECT 20UF 450VDCW	
C125	0180-0039	C:FXD ELECT 100UF 12VDCW	
CR1	1901-0036	SEMICON DEVICE:DIODE SILICON 1000PIV 0.3A	
CR2	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
CR3	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
CR4	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
CR5	1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	
DS1	2140-0009	LAMP:INCANDESCENT 6-8V TYPE 47	
F1	2110-0014	FUSE:CARTRIDGE 4 AMP 125V SLOW BLOW FOR 115 V OPERATION	
F1	2110-0006	FUSE:CARTRIDGE 2AMP 250V SLOW BLOW FOR 230 V OPERATION	
F2 THRU F100		NOT ASSIGNED	
F101	2110-0012	FUSE,CARTRIDGE 1/2AMP 250V	
J1	1250-0001	CONNECTOR:BNC	
J2 THRU J100		NOT ASSIGNED	
J101		CONSISTS OF:	
	0340-0086	INSULATOR:BINDING POST	
	0340-0089	BINDING POST:SINGLE	
	5060-0632	BINDING POST:BLACK	
	5060-0633	BINDING POST:RED	
J102	1251-0070	JACK:PHONE PEN LIFT	
J103	1251-0096	JACK:5-CONTACT FEMALE	
J104	1251-0082	JACK:7-CONTACT FEMALE	
J105		CONSISTS OF:	
	0340-0086	INSULATOR:BINDING POST	
	0340-0088	TERMINAL:TURRET	
	5060-0632	BINDING POST:BLACK	
	5060-0633	BINDING POST:RED	

See list of abbreviations in introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗⓟ Stock No.	Description #	Note
L1	9140-0018	COIL:FXD 1UH	
L2	9140-0018	COIL:FXD 1UH	
L3	9140-0018	COIL:FXD 1UH	
L4	9140-0018	COIL:FXD 1UH	
L5	9140-0042	COIL:VAR .27-.41 UH	
L6	9140-0043	COIL:VAR 1.2-1.75 UH	
L7	9140-0042	COIL:VAR .27-.41 UH	
L8	9140-0043	COIL:VAR 1.2-1.75 UH	
L9	9140-0042	COIL:VAR .27-.41 UH	
L10	9140-0043	COIL:VAR 1.2-1.75 UH	
L11	9140-0042	COIL:VAR .27-.41 UH	
L12	9140-0043	COIL:VAR 1.2-1.75 UH	
L13	9140-0041	COIL:FXD RF 2.5 MH	
L14 THRU			
L100		NOT ASSIGNED	
L101	9110-0024	REACTOR:POWER: 1HY 250MA	
M1 THRU			
M100		NOT ASSIGNED	
M101	1120-0068	MILLIAMMETER:0-1 MILLIAMPERES	
P1	8120-0015	POWER CABLE	
R1	0693-1841	R:FXD COMP 180K OHM 10% 2W	
R2	0819-0012	R:FXD WW 15 OHM 10% 20W	
R3	0816-0010	R:FXD WW 12 OHM 10% 10W	
R4	2100-0033	R:VAR WW 10 OHM 20% LIN 1W	
R5		NOT ASSIGNED	
R6	0819-0003	R:FXD WW 5000 OHM 10% 20W	
R7	0819-0017	R:FXD WW 2500 OHM 10% 20W	
R8	0690-2741	R:FXD COMP 270K OHM 10% 1W	
R9	0687-8231	R:FXD COMP 82K OHM 10% 1/2W	
R10	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R11	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R12	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R13	0690-1241	R:FXD COMP 120K OHM 10% 1W	
R14	0687-2741	R:FXD COMP 270K OHM 10% 1/2W	
R15	0730-0074	R:FXD DEPC 144K OHM 1% 1W	
R16	2100-0009	R:VAR WW 25K OHM LIN 1/3W	
R17	0730-0058	R:FXD DEPC 75K OHM 1% 1W	
R18	0730-0087	R:FXD DEPC 370K OHM 1% 1W	
R19	0730-0085	R:FXD DEPC 316K OHM 1% 1W	
R20	0690-1801	R:FXD COMP 18 OHM 10% 1W	
R21	0687-5601	R:FXD COMP 56 OHM 10% 1/2W	
R22	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
R23	0693-1531	R:FXD COMP 1 K OHM 10% 2W	
R24	0690-1531	R:FXD COMP 15K OHM 10% 1W	
R25	0687-3321	R:FXD COMP 3300 OHM 10% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
R26	0687-2711	R:FXD COMP 270 OHM +/-10% 1/2W	

See list of abbreviations in introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	hp Stock No.	Description #	Note
R27	0690-4731	R:FXD COMP 47K OHM 10% 1W	
R28	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
R29	0693-1531	R:FXD COMP 15K OHM 10% 2W	
R30	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R31	0690-1531	R:FXD COMP 15K OHM 10% 1W	
R32	0687-2711	R:FXD COMP 270 OHM +/-10% 1/2W	
R33	0690-4731	R:FXD COMP 47K OHM 10% 1W	
R34	0687-3321	R:FXD COMP 3300 OHM 10% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
R35	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
R36	0693-1531	R:FXD COMP 1 K OHM 10% 2W	
R37	0690-1531	R:FXD COMP 15K OHM 10% 1W	
R38	0687-2711	R:FXD COMP 270 OHM +/-10% 1/2W	
R39	0690-4731	R:FXD COMP 47K OHM 10% 1W	
R40	0687-3321	R:FXD COMP 3300 OHM 10% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
R41	0693-1531	R:FXD COMP 1 K OHM 10% 2W	
R42	0687-1011	R:FXD COMP 100 OHM 10% 1/2W	
R43	0690-1531	R:FXD COMP 15K OHM 10% 1W	
R44	0687-3321	R:FXD COMP 3300 OHM 10% 1/2W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
R45	0690-4731	R:FXD COMP 47K OHM 10% 1W	
R46	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
R47	0687-4721	R:FXD COMP 4700 OHM 10% 1/2W	
R48	0687-1031	R:FXD COMP 10K OHM 10% 1/2W	
R49	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R50	0687-1541	R:FXD COMP 150K OHM 10% 1/2W	
R51 THRU R58		NOT ASSIGNED	
R59	0763-0004	R:FXD FLM 23K OHM 2% 2W	
R60	0730-0020	R:FXD DEPC 3030 OHM 1% 1W	
R61 THRU R100		NOT ASSIGNED	
R101	0687-4731	R:FXD COMP 47K OHM 10% 1/2W	
R102	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R103	2100-0015	R:VAR COMP 500K OHM LIN 1/4W	
R104	0727-0255	R:FXD DEPC 800K OHM 1% 1/2W	
R105	0687-1031	R:FXD COMP 10K OHM 10% 1/2W	
R106	0730-0039	R:FXD DEPC 22K OHM 1% 1W	
R107	0687-1811	R:FXD COMP 180 OHM 10% 1/2W	
R108	0727-0217	R:FXD DEPC 140K OHM 1% 1/2W	
R109	2100-0073	R:VAR COMP 125K OHM 20% LIN 1/4W	
R110	0727-0214	R:FXD DEPC 120K OHM 1% 1/2W	
R111	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R112	0687-3921	R:FXD COMP 3900 OHM 10% 1/2W	
R113	0687-1031	R:FXD COMP 10K OHM 10% 1/2W	
R114	0764-0019	R:FXD MET FLM 3900 OHM 5% 2W	
R115	0687-1811	R:FXD COMP 180 OHM 10% 1/2W	
R116	0727-0131	R:FXD DEPC 3920 OHM 1% 1/2W	
R117	0730-0002	R:FXD DEPC 40.40 OHM 1% 1W	
R118	0727-0132	R:FXD DEPC 4000 OHM 1% 1/2W	

See list of abbreviations in introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗⓟ Stock No.	Description #	Note
R119	0730-0002	R:FXD DEPC 40.40 OHM 1% 1W	
R120	2100-0005	R:VAR WW 2000 OHM 10% LIN 2W	
R121	2100-0197	R:VAR WW 2000 10% 2W COMP 200 OHM 20% 0.3W	
R122	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
R123	0690-8231	R:FXD COMP 82K OHM 10% 1W	
R12	0687-3331	R:FXD COMP 33K OHM 10% 1/2W	
R125	0690-8231	R:FXD COMP 82K OHM 10% 1W	
R126	0693-4731	R:FXD COMP 47K OHM 10% 2W	
R127	2100-0053	R:VAR WW 10K OHM 20% LIN 2W	
R128	0687-1031	R:FXD COMP 10K OHM 10% 1/2W	
R129	0687-2741	R:FXD COMP 270K OHM 10% 1/2W	
R130	0767-0011	R:FXD MET OX 20K OHM 5% 3W	
R131	0686-3655	R:FXD COMP 3.5 MEGOHM 5% 1/2W	
R132	0686-3655	R:FXD COMP 3.5 MEGOHM 5% 1/2W	
R133	0767-0011	R:FXD MET OX 20K OHM 5% 3W	
R134	0687-1551	R:FXD COMP 1.5 MEGOHM 10% 1/2W	
R135	0687-2261	R:FXD COMP 22 MEGOHM 10% 1/2W	
R136	0687-3951	R:FXD COMP 3.9 MEGOHM 10% 1/2W	
R137	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R138	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R139	0693-4731	R:FXD COMP 47K OHM 10% 2W	
R140	0687-5651	R:FXD COMP 5.6 MEGOHM 10% 1/2W	
R141	0687-1061	R:FXD COMP 10 MEGOHM 10% 1/2W	
R142	0687-1061	R:FXD COMP 10 MEGOHM 10% 1/2W	
R143	0687-5651	R:FXD COMP 5.6 MEGOHM 10% 1/2W	
R144	0693-4731	R:FXD COMP 47K OHM 10% 2W	
R145	0687-3951	R:FXD COMP 3.9 MEGOHM 10% 1/2W	
R146	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R147	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R148	0687-2261	R:FXD COMP 22 MEGOHM 10% 1/2W	
R149	0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	
R150	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
R151	0816-0018	R:FXD WW 20K OHM 5% 10W	
R152	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
R153	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R154	2100-0170	R:VAR WW 1000 OHM 20% LIN 25W	
R155	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R156	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
R157	0687-4721	R:FXD COMP 4700 OHM 10% 1/2W	
R158	0819-0018	R:FXD WW 500 OHM 10% 50W	
R159	0819-0019	R:FXD WW 100 OHM 10% 20W	
R160	0816-0008	R:FXD WW 10K OHM 10% 10W	
R161	0690-4701	R:FXD COMP 47 OHM 10% 1W	
R162		NSR PART OF R121	
R163	0690-4711	R:FXD COMP 470 OHM 10% 1W	
R164	0687-8251	R:FXD COMP 8.2 MEGOHM 10% 1/2W	
R165	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R166	0689-3915	R:FXD COMP 390 OHM 5% 1W	
RT1	0852-0004	TUBE:BALLAST 10-4C	
S1	3101-0030	SWITCH:TOG SPST 15 AMP 125 VAC	

See list of abbreviations in introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation		Stock No.	Description #	Note
S2		3100-0155	SWITCH-ROTARY: 4 SECT 2 POS	
S3	THRU			
S100			NOT ASSIGNED	
S101		3100-0165	SWITCH-ROTARY: 2 POS 1 SECT	
S102		340B-19B	METER FUNCTION SWITCH ASSEMBLY	
S103		340B-19C	NOISE SOURCE SWITCH ASSEMBLY	
T1		9100-0098	TRANSFORMER:POWER	
T2	THRU			
T100			NOT ASSIGNED	
T101		9120-0034	TRANSFORMER:AUDIO	
V1		1930-0008	ELECTRON TUBE: 5U4GA/B	
V2		1932-0019	ELECTRON TUBE: 6AS7GA DUO-TRIODE	
V3		1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
V4		1940-0001	ELECTRON TUBE:5651	
V5		1940-0004	ELECTRON TUBE: 0A2 VOLTAGE REGULATOR	
V6		1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
V7		1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
V8		1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
V9		1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
V10		1932-0015	ELECTRON TUBE: 6922 TWIN TRIODE	
V11	THRU			
V100			NOT ASSIGNED	
V101		1932-0015	ELECTRON TUBE: 6922 TWIN TRIODE	
V102		1930-0013	ELECTRON TUBE: 6AL5 TWIN DIODE	
V103		1932-0015	ELECTRON TUBE: 6922 TWIN TRIODE	
V104		1932-0029	ELECTRON TUBE: 12AU7 DUAL TRIODE	
V105		1930-0013	ELECTRON TUBE: 6AL5 TWIN DIODE	
V106		1932-0029	ELECTRON TUBE: 12AU7 DUAL TRIODE	
V107		1923-0018	ELECTRON TUBE: 6AQ5 BEAM PENTODE	
V108		1932-0019	ELECTRON TUBE: 6AS7GA DUO-TRIODE	
V109		1923-0029	ELECTRON TUBE: 6CD6GA BEAM PENTODE OCTAL	
V110		1921-0010	ELECTRON TUBE: 12B4A TROIDE 9 PIN MINIAT	
V111		1921-0010	ELECTRON TUBE: 12B4A TRIODE 9 PIN MINIAT	
			MISCELLANEOUS	
		340A-16A	CABLE ASSEMBLY,CONSISTS OF:	
		1251-0080	PLUG:7-CONTACT MALE	
		1251-0081	PLUG:7-CONTACT FEMALE	
		8120-0076	CABLE:1-COAXIAL 3-SINGLE CONDUCTORS	
		1401-0006	CLIP:TUBE CERAMIC INSULATION	
		340B-40A	DIAL ASSEMBLY	
		1400-0084	HOLDER:FUSE POST TYPE 3AG	
		1450-0020	JEWEL:PILOT LIGHT RED FACETED PLASTIC	
		0370-0024	KNOB:BLK W/ARROW 3/4 IN. OD 3/16 IN. SAFT	
		0370-0026	KNOB,BLK W/ARROW 3/4 IN. OD 1/8 IN. SHAFT	
		0370-0029	KNOB:BLK W/ARROW 1 IN. OD 1/4 IN. SHAFT	
		0370-0035	KNOB:BLK BAR W/ARROW 1 IN. OD 1/4IN. SHAFT	
		0370-0067	KNOB:BLK CONCENTRIC 1 IN. OD 17/64IN. HOLE	
		1450-0019	LAMPHOLDER:PILOT LIGHT	
		3150-0002	OIL:AIR FL,WATER SOLUBLE OIL	
		1200-0008	SOCKET:TUBE 9-PIN	

See list of abbreviations in introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗⓟ Stock No.	Description #	Note
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
	1200-0020	JACK:OCTAL FEMALE MICA-FILLED PHENOLIC	
	1220-0009	SHIELD-TUBE	
	1220-0010	SHIELD:ELECTRON TUBE	

See list of abbreviations in introduction to this section

Table 5-2. Replaceable Parts

hp Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
0140-0005	C:FXD MICA 27 PF 10% 500VDCW	00853	RCM15E270K	2	
0140-0049	C:FXD MICA 68 PF 5% 500 VDCW	76433	CM15C680J	1	
0140-0054	C:FXD MICA 100 PF 10% 500 VDCW	00853	RCM15E101K	2	
0140-0168	C:FXD MICA SIL 330 PF 5% 300 VDCW	00853	RCM15E331J	2	
0150-0050	C:FXD CER 1000PF 600 VDCW	84411	TYPE E	29	
0150-0051	C:FXD CER 100 PF 600 VDCW	84411	OBD	2	
0160-0001	C:FXD MY 0.1UF 10% 600VDCW	28480	0160-0001	1	
0160-0002	C:FXD MY .01UF 10% 600VDCW	56289	160P10396	4	
0160-0005	C:FXD MY 0.047UF 10% 600VDCW	28480	0160-0005	6	
0160-0013	C:FXD MY 0.1UF 10% 400VDCW	56289	160P10494	3	
0160-0015	C:FXD PAPER 0.47UF 10% 200VDCW	56289	109P47492	3	
0160-0059	C:FXD PAPER 470PF 20% 6000VDCW	72354	184P471060	1	
0170-0022	C:FXD MY 0.1UF 20% 600VDCW	09134	TYPE 24	1	
0180-0011	C:FXD ELECT 20UF 450VDCW	28480	0180-0011	4	
0180-0025	C:FXD ELECT 4 SECT 20UF 450VDCW	56289	D32452	1	
0180-0030	C:FXD ELECT 120-40 UF 450VDCW	28480	0180-0030	1	
0180-0039	C:FXD ELECT 100UF 12VDCW	56289	30D32697	1	
0180-0045	C:FXD ELECT 20UF 25VDCW	56289	30D206-G0-25DB-6M1	1	
0340-0086	INSULATOR:BINDING POST	28480	0340-0086	2	
0340-0088	TERMINAL:TURRET	95264	4545C	1	
0340-0089	BINDING POST:SINGLE	28480	0340 0089	1	
0370-0024	KNOB:BLK W/ARROW 3/4 IN. OD 3/16 IN. SAFT	28480	0370-0024	1	
0370-0026	KNOB:BLK W/ARROW 3/4 IN. OD 1/8 IN. SHAFT	28480	0370-0026	1	
0370-0029	KNOB:BLK W/ARROW 1 IN. OD 1/4 IN. SHAFT	28480	0370-0029	1	
0370-0035	KNOB:BLK BAR W/ARROW 1 IN. OD 1/4IN. SHAFT	28480	0370-0035	2	
0370-0067	KNOB:BLK CONCENTRIC 1 IN. OD 17/64IN. HOLE	28480	0370-0067	1	
0686-3655	R:FXD COMP 3.5 MEGOHM 5% 1/2W	01121	EB 3655	2	
0687-1011	R:FXD COMP 100 OHM 10% 1/2W	01121	EB 1011	4	
0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	01121	EB 1021	6	
0687-1031	R:FXD COMP 10K OHM 10% 1/2W	01121	EB 1031	4	
0687-1051	R:FXD COMP 1 MEGOHM 10% 1/2W	01121	EB 1051	9	
0687-1061	R:FXD COMP 10 MEGOHM 10% 1/2W	01121	EB 1061	2	
0687-1541	R:FXD COMP 150K OHM 10% 1/2W	01121	EB 1541	1	
0687-1551	R:FXD COMP 1.5 MEGOHM 10% 1/2W	01121	EB 1551	1	
0687-1811	R:FXD COMP 180 OHM 10% 1/2W	01121	EB 1811	2	
0687-2261	R:FXD COMP 22 MEGOHM 10% 1/2W	01121	EB 2261	2	
0687-2711	R:FXD COMP 270 OHM +/-10% 1/2W	01121	EB 2711	3	
0687-2741	R:FXD COMP 270K OHM 10% 1/2W	01121	EB 2741	2	
0687-3321	R:FXD COMP 3300 OHM 10% 1/2W	01121	EB 3321	4	
0687-3331	R:FXD COMP 33K OHM 10% 1/2W	01121	EB 3331	2	
0687-3921	R:FXD COMP 3900 OHM 10% 1/2W	01121	EB 3921	1	
0687-3951	R:FXD COMP 3.9 MEGOHM 10% 1/2W	01121	EB 3951	2	
0687-4721	R:FXD COMP 4700 OHM 10% 1/2W	01121	EB 4721	2	
0687-4731	R:FXD COMP 47K OHM 10% 1/2W	01121	EB 4731	2	
0687-4741	R:FXD COMP 470K OHM 10% 1/2W	01121	EB 4741	3	
0687-5601	R:FXD COMP 56 OHM 10% 1/2W	01121	EB 5601	1	
0687-5651	R:FXD COMP 5.6 MEGOHM 10% 1/2W	01121	EB 5651	2	
0687-8231	R:FXD COMP 82K OHM 10% 1/2W	01121	EB 8231	1	
0687-8251	R:FXD COMP 8.2 MEGOHM 10% 1/2W	01121	EB 8251	1	
0689-3915	R:FXD COMP 390 OHM 5% 1W	01121	GB 3915	1	

See list of abbreviations in introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

ⓗ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
0690-1241	R:FXD COMP 120K OHM 10% 1W	01121	GB 1241	1	
0690-1531	R:FXD COMP 15K OHM 10% 1W	01121	CB 1531	4	
0690-1801	R:FXD COMP 18 OHM 10% 1W	01121	GB 1801	1	
0690-2741	R:FXD COMP 270K OHM 10% 1W	01121	GB 2741	1	
0690-4701	R:FXD COMP 47 OHM 10% 1W	01121	GB 4701	1	
0690-4711	R:FXD COMP 470 OHM 10% 1W	01121	GB 4711	1	
0690-4731	R:FXD COMP 47K OHM 10% 1W	01121	GB 4731	4	
0690-8231	R:FXD COMP 82K OHM 10% 1W	01121	GB-8231	2	
0693-1531	R:FXD COMP 1 K OHM 10% 2W	01121	HB 1531	4	
0693-1841	R:FXD COMP 180K OHM 10% 2W	01121	HB 1841	1	
0693-4731	R:FXD COMP 47K OHM 10% 2W	01121	HB 4731	3	
0727-0131	R:FXD DEPC 3920 OHM 1% 172W	28480	0727-0131	1	
0727-0132	R:FXD DEPC 4000 OHM 1% 1/2W	28480	0727-0132	1	
0727-0214	R:FXD DEPC 120K OHM 1% 1/2W	28480	0727-0214	1	
0727-0217	R:FXD DEPC 140K OHM 1% 1/2W	28480	0727-0217	1	
0727-0255	R:FXD DEPC 800K OHM 1% 1/2W	28480	0727-0255	1	
0730-0002	R:FXD DEPC 40.40 OHM 1% 1W	28480	0730-0002	2	
0730-0020	R:FXD DEPC 3030 OHM 1% 1W	28480	0730-0020	1	
0730-0039	R:FXD DEPC 22K OHM 1% 1W	28480	0730-0039	1	
0730-0058	R:FXD DEPC 75K OHM 1% 1W	28480	0730-0058	1	
0730-0074	R:FXD DEPC 144K OHM 1% 1W	28480	0730-0074	1	
0730-0085	R:FXD DEPC 316K OHM 1% 1W	28480	0730-0085	1	
0730-0087	R:FXD DEPC 370K OHM 1% 1W	28480	0730-0087	1	
0763-0004	R:FXD FLM 23K OHM 2% 2W	07115	STYLE S 25	1	
0764-0019	R:FXD MET FLM 3900 OHM 5% 2W	28480	0764-0019	1	
0767-0011	R:FXD MET OX 20K OHM 5% 3W	28480	0767-0011	2	
0816-0008	R:FXD WW 10K OHM 10% 10W	28480	0816-0008	1	
0816-0010	R:FXD WW 12 OHM 10% 10W	28480	0816-0010	1	
0816-0018	R:FXD WW 20K OHM 5% 10W	28480	0816-0018	1	
0819-0003	R:FXD WW 5000 OHM 10% 20W	28480	0819-0003	1	
0819-0012	R:FXD WW 15 OHM 10% 20W	28480	0819-0012	1	
0819-0017	R:FXD WW 2500 OHM 10% 20W	28480	0819-0017	1	
0819-0018	R:FXD WW 500 OHM 10% 50W	56289	50KT 500	1	
0819-0019	R:FXD WW 100 OHM 10% 20W	28480	0819-0019	1	
0852-0004	TUBE:BALLAST 10-4C	70563	10-4C	1	
1120-0068	MILLIAMMETER:0-1 MILLIAMPERES	28480	1120-0068	1	
1200-0008	SOCKET:TUBE 9-PIN	71785	121-25-11-055	7	
1200-0009	SOCKET:TUBE 7-PIN MINAT	91662	04-703-05	10	
1200-0020	JACK:OCTAL FEMALE MICA-FILLED PHENOLIC	71785	101-12-11-046	5	
1220-0009	SHIELD-TUBE	71785	151-11-23-012	1	
1220-0010	SHIELD:ELECTRON TUBE	71785	150-11-23-012	1	
1250-0001	CONNECTOR:BNC	91737	5126	1	
1251-0070	JACK:PHONE PEN LIFT	82389	2J-1581	1	
1251-0080	PLUG:7-CONTACT MALE	71468	GK-R7-22C 1/2	1	
1251-0081	PLUG:7-CONTACT FEMALE	71468	GK-R7-21C 1/2 (F-67)	1	
1251-0082	JACK:7-CONTACT FEMALE	71468	GK-R7-31S (F-67)	1	
1251-0096	JACK:5-CONTACT FEMALE	24446	WK-5-31S	1	
1400-0084	HOLDER:FUSE POST TYPE 3AG	75915	342014	2	
1401-0006	CLIP:TUBE CERAMIC INSULATION	76487	36002	1	
1450-0019	LAMPHOLDER:PILOT LIGHT	72765	D223H-AEN	1	

See list of abbreviations in introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
1450-0020	JEWEL:PILOT LIGHT RED FACETED PLASTIC	72765	14L-113	1
1901-0028	DIODE:SILICON 400 PIV 0.5 AMP	28480	1901-0028	4
1901-0036	SEMICON DEVICE:DIODE SILICON 1000PIV 0.3A	28480	1901-0036	1
1921-0010	ELECTRON TUBE: 12B4A TROIDE 9 PIN MINIAT	33173	12B4A	2
1923-0018	ELECTRON TUBE: 6AQ5 BEAM PENTODE	93332	6AQ5	1
1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	33173	6AU6	5
1923-0029	ELECTRON TUBE: 6CD6GA BEAM PENTODE OCTAL	86684	6CD6GA	1
1930-0008	ELECTRON TUBE: 5U4GA/B	86684	5U4GA/B	1
1930-0013	ELECTRON TUBE: 6AL5 TWIN DIODE	33173	6AL5	2
1932-0015	ELECTRON TUBE: 6922 TWIN TRIODE	73445	6922	3
1932-0019	ELECTRON TUBE: 6AS7GA DUO-TRIODE	33173	6AS7GA	2
1932-0029	ELECTRON TUBE: 12AU7 DUAL TRIODE	12859	12AU7	2
1940-0001	ELECTRON TUBE:5651	86684	5651A	1
1940-0004	ELECTRON TUBE: OA2 VOLTAGE REGULATOR	86684	OA2	1
2100-0005	R:VAR WW 2000 OHM 10% LIN 2W	28480	2100-0005	1
2100-0009	R:VAR WW 25K OHM LIN 1/3W	28480	2100-0009	1
2100-0015	R:VAR COMP 500K OHM LIN 1/4W	28480	2100-0015	1
2100-0033	R:VAR WW 10 OHM 20% LIN 1W	28480	2100-0033	1
2100-0053	R:VAR WW 10K OHM 20% LIN 2W	28480	2100-0053	1
2100-0073	R:VAR COMP 125K OHM 20% LIN 1/4W	28480	2100-0073	1
2100-0170	R:VAR WW 1000 OHM 20% LIN 25W	28480	2100-0170	1
2100-0197	R:VAR WW 2000 10% 2W COMP 200 OHM 20% 0.3W	28480	2100-0197	1
2110-0006	FUSE:CARTRIDGE 2AMP 250V SLOW BLOW	71400	MDL2	1
2110-0012	FUSE,CARTRIDGE 1/2AMP 250V	75915	312500	1
2110-0014	FUSE:CARTRIDGE 4 AMP 125V SLOW BLOW	71400	MDX-4	1
2140-0009	LAMP:INCANDESCENT 6-8V TYPE 47	24455	47	1
3100-0155	SWITCH-ROTARY: 4 SECT 2 POS	28480	3100-0155	1
3100-0165	SWITCH-ROTARY: 2 POS 1 SECT	28480	3100-0165	1
3101-0030	SWITCH:TOG SPST 15 AMP 125 VAC	88140	8906K368	1
3140-0010	MOTOR:AC 1/175 HP 2800 RPM	73793	ER 6667	1
3150-0002	OIL:AIR FL,WATER SOLUBLE OIL	82866	SN 411	1
3150-0004	FL:AIR 7 IN X 7 IN X 1/2 IN	82866	807390	1
3160-0011	BLADE:FAN 5 BLADES, 5-1/2 DIA	06812	0 5527 5/CCW	1
3160-0012	BLADE:FAN 5 BLADES 5-1/2 DIA	06812	0 5527 5/CW	1
5060-0632	BINDING POST:BLACK	28480	5060-0632	2
5060-0633	BINDING POST:RED	28480	5060-0633	2
8120-0015	POWER CABLE	70903	KH3981/PH70/7.5FT	1
8120-0076	CABLE:1-COAXIAL 3-SINGLE CONDUCTORS	28480	8120-0076	1
9100-0098	TRANSFORMER:POWER	28480	9100-0098	1
9110-0024	REACTOR:POWER: 1HY 250MA	98734	1317	1
9120-0034	TRANSFORMER:AUDIO	28480	9120-0034	1
9140-0018	COIL:FXD 1UH	99848	205-11-10	4
9140-0041	COIL:FXD RF 2.5 MH	28480	9140-0041	1
9140-0042	COIL:VAR .27-.41 UH	28480	9140-0042	4
9140-0043	COIL:VAR 1.2-1.75 UH	28480	9140-0043	4
340A-16A	CABLE ASSEMBLY	28480	340A-16A	1
340B-40A	DIAL ASSEMBLY	28480	340B-40A	1
340B-19B	METER FUNCTION SWITCH ASSEMBLY	28480	340B-19B	1
340B-19C	NOISE SOURCE SWITCH ASSEMBLY	28480	340B-19C	1

See list of abbreviations in introduction to this section

TABLE 5-3.

CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00334	Humidial	Colton, Calif.
00373	Garlock Inc., Electronics Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Labortories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp.	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Rubber and Plastics Inc.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.,Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div., Finderne Plant	Somerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illimitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c/o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Plainview, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices Inc.	Burbank, Calif.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Nuclear Corp. of America U.S. Semcor Div.	Phoenix, Ariz.
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
06980	Eitel-McCullough Inc.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Camera & Inst. Corp., Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls,Ontario, Canada
08664	The Bristol Co.	Waterbury, Conn.
08717	Sloan Company	Sun Valley,Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S.,Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley,Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne,Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components,Inc.	Conshohocken, Pa.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15291	Adjustable Bushing Co.	N.Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15818	Amelco Inc.	Mt. View, Calif.
15909	Daven Div. Thomas A. Edison Ind. McGraw-Edison Co.	Long Island City, N.Y.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18476	Ty-Car Mfg. Co.,Inc.	Holliston, Mass.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co.,Inc.	Wilmington, Del.
19315	The Bendix Corp., Eclipse-Pioneer Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co.,Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co.,Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St.Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N Y
64959	Western Electric Co.,Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Revere Wollansak Div. Minn. Mining & Mfg. Co.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allen Mfg. Co.	Hartford, Conn.
70318	Allmetal Screw Product Co. Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co.,Inc.	Union City, N. J.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co.,Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N. Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co.,Inc.	Willimantic, Conn.
71707	Coto Coil Co.,Inc.	Providence, R.I.
72354	John E. Fast Co., Div. Victoreen Instr. Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N. Y.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	General Instrument Corp., Micamold Div.	Newark, N.J.
76487	James Millen Mfg. Co.,Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	The Bendix Corp. Bendix Pacific Div.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Stuthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80130	Times Telephoto Equipment	New York, N.Y.
80131	Electronic Industries Association. Any brand Tube meeting EIA standards-	Washington, D.C.
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Robertshaw Controls Co.	Hillsboro, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.

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From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

TABLE 5-3.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
80583	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Calif.
81349	Military Specification	....
81415	Wilkor Products, Inc.	Cleveland, Ohio
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Div. Barry Wright Corp.	Waterton, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Cooper Hewitt Electric Div.	Hoboken, N.J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp., Defense Prod. Division	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa.
82376	Astron Division, Renwell Industries Inc.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfg. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co. Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Div. National Carbon Div. Union Carbide Corp.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co.	San Francisco, Calif.
85474	R.M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of America, Electronic Comp. & Devices Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88421	Federal Telephone & Radio Corp.	Clifton, N.J.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
89665	United Transformer Co.	Chicago, Ill.
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co., Inc.	Rochester, N.Y.
92196	Universal Industries, Inc.	City of Industry, Calif.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
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94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
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94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products Memcor Components Div.	Huntington, Ind.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
95023	George A. Philbrick Researchers, Inc.	Boston, Mass.
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95712	Dage Electric Co., Inc.	Franklin, Ind.
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96067	Huggins Laboratories	Sunnyvale, Calif.
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96256	Thordarson-Meissner Div. of Maguire Industries, Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
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96501	Excel Transformer Co.	Oakland, Calif.
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97539	Automatic & Precision Mfg.	Englewood, N.J.
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97983	Litton System Inc., Adler-Westric Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
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THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

Code No.	Manufacturer	Address
0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000AK	Siemens-America Components Div.	White Plains, N.Y.
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000SS	Control of Elgin Watch Co.	Burbank, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

00015-40
Revised: May, 1965

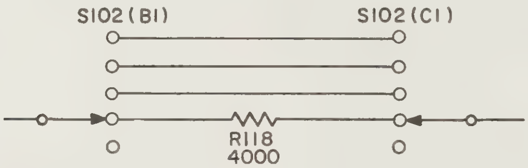
From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

APPENDIX
MANUAL CHANGES

This manual applies directly to instruments with serial prefix 416-. For other prefixes, make the manual changes indicated in the table below. If the prefix on your instrument is not shown either here or on a change sheet enclosed with the manual, the correct information may be obtained from your nearest Hewlett-Packard Sales and Service Office (see lists at the back of this manual).

Instrument Serial No.	Manual Changes
324-, 229-	1
221-	1, 3
041-	1, 2, 3
004-00476 and below	1, 2

CHANGE 1 C125: Delete
Change S102 (B1-C1) circuit as shown below:



CHANGE 2 C107: Change to capacitor, fixed, mica, 270 pf ±10%, 500 vdcw ⓗⓟ Stock No. 0140-0015.
CR1: Change to Rectifier, metallic: 405 vrms, ⓗⓟ Stock No. 1880-0011.
Add: R5: Resistor fixed, composition, 150 ohms ±10%, 2W, ⓗⓟ Stock No. 0693-1511.
R6: Change to resistor, fixed, wirewound, 2.5K ohms ±10%, 20 W, ⓗⓟ Stock No. 0819-0017.
R19: Change to resistor, fixed, deposited carbon, 265K ohms ±1%, 1W, ⓗⓟ Stock No. 0730-0082.
R129: Change to resistor, fixed, composition, 560K ohms ±10%, 1/2W, ⓗⓟ Stock No. 0687-5641.
R143: Change to "same as R140".

CHANGE 3 C109, 110: Change to capacitor, fixed, mica, 220 pf ±10%, 500 vdcw, ⓗⓟ Stock No. 0140-0031.
CR2, 3, 4, 5: Change ⓗⓟ Stock No. to 1901-0028.
R131, 132: Change to resistor, fixed, composition, 5.6M ±10%, 1/2W, ⓗⓟ Stock No. 0687-5651; TQ 4.

CHANGE 4 Add R51, 52, 53, and 54: Resistor, fixed, compositon 4700 ohms ±10%, 1/2W; ⓗⓟ Stock No. 0687-4721. Optimum value selected at factory; average value shown.
Shunt coils for these resistors are L5, 7, 9, and 11.

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